N2Africa Podcaster no. 53
PhD and MSc Student Special

July and August 2018

Introduction

The urgent and continuing need for capacity building to develop the next generation of agricultural experts working across the food system is often highlighted as a major priority in high-level policy documents. N2Africa has contributed to capacity development at all levels from smallholder farmers across the value chains and broader agricultural and food system. This is an area that we will be studying in our ongoing impact evaluations. In this Podcaster we have an annual update from the PhD candidates working within N2Africa. We also have a short report on the N2Africa presentations at the European Nitrogen Fixation Conference 2018 that was held in Stockholm recently.

During our last N2Africa Advisory Committee meeting that was held in May in Kigali, the question arose as to what has happened to all of the students who studied through N2Africa. This is a really interesting question - we now have in total 70 MSc theses and internship reports on the N2Africa website (http://www.n2africa.org/mscbscinternship?order=field_report_code&sort=asc). Where are they all now? Over the past couple of months we've tracked down our past students as far as possible, asked them where they are now and we share their stories with you here. The responses are rich and varied and a great testament to the broader and sometimes less tangible impacts of N2Africa. We do not have current email addresses for all of our past students so if you can put us in thouch with those who do not report here we'll be pleased to get in touch and carry their news updates.

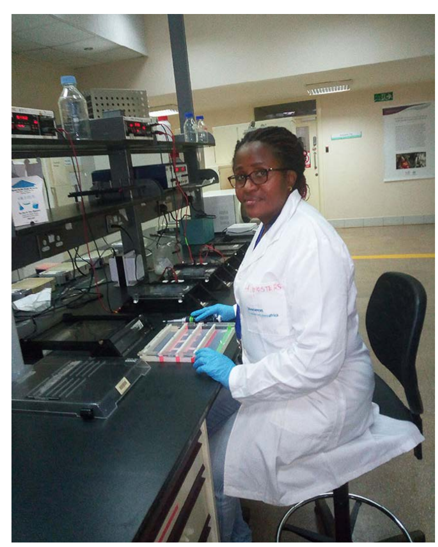
Current activities of the N2Africa teams across the countries are focused very much on impact studies through which we want to learn about outputs and outcomes of our work over the past nine years and they are contributing to long term impacts. We'll report on these impact studies in future podcasters but for now enjoy reading the news from our current and past students.

Ken Giller

Genetic diversity and genetic component associated with high Nitrogen fixation in indigenous rhizobia nodulating soyabean in South Kivu, Eastern Democratic Republic of Congo

After her MSc within N2Africa Bintu Nabintu Ndusha is enrolled for PhD at University of Nairobi since 2016 and is working under the supervision of Prof. Shellemia Keya and Richard Onwonga of UoN, Dr Leon Nabahungu of IITA and Prof. Gustave Nachigera from her home institute, Université Evangelique en Afrique. She did her Master's studies under N2 Africa program in 2011 and after her masters she applied for African Bioscience Challenge Fund (ABCF) of BecA-ILRI hub to perform molecular studies on rhizobia isolates obtained by N2Africa in Congo. She obtained CORAF-WECARD/IITA and RUFORUM grants for her field data collection but she is also supported by the Organization of Women in Science for Developing Countries (OWSD). Her PhD project is on **genetic diversity and genetic component associated with nitrogen fixation in indigenous rhizobia nodulating soyabean in South Kivu**.

Soyabean is an important legume amongst legumes in term of being a crucial source of protein and most consumed edible oil. Apart from its high nutrition value, this crop is capable to fix naturally nitrogen from atmosphere in symbiotic association with bacteria of the *Rhizobium* genus trough Biological Nitrogen Fixation process. Despite their importance in improving nutrition, food security and soil fertility, soyabean yield in South Kivu remains among the lowest in the world; only 0.5t ha^{-1}. This low yield of soyabean is attributed to a number of factors and the main factors in South Kivu include declining soil fertility accentuated by low use of fertilizers, access to input and improved varieties and poor agronomic practices.



Picture one: Bintu Ndusha performing a gel electrophoresis to check DNA quality of rhizobia isolates form D.R.Congo in BecA-ILRI molecular laboratory.

BNF is the best option to improve production of legumes. The use in inoculants of highly effective and adapted rhizobia strains is necessary where the soil does not contain high population of indigenous rhizobia. The gene based-characterization methods are accurate and time saving way to characterize and select high effective rhizobia for inoculants production. The sequencing of genome enables to identify caracteristics associated with compatibility with host and ability of nitrogen fixation in *Rhizobium*. This method can assess also factors associated with environmental fitness, saprophytic competence and competitiveness for nodule occupancy.

This study is therefore investigating the genetic diversity and the genetic component associated with N fixation in indigenous rhizobia isolated from South Kivu soil. In addition, the current study will test selected strains for their competitiveness for nodule occupancy and their effectiveness in improving BNF and productivity of soyabean in different soils conditions in South Kivu. For the genetic diversity assessment, three types of genes were used namely: 16s rRNA, housekeeping genes (recA, atpD and glnII) and symbiotic genes (nodA and nifH). Genes used to assess the genetic diversity of indigenous rhizobia are presented in the table 1. To determine the genetic component associated with Nitrogen fixation, the full genome sequencing was performed on Illumina Miseq at BecA-ILRI hub/Kenya. Genomes characteristics were compared to the references genes by the Bidirectional Best Hit (BBH) approach and gene annotation was performed by genes annotation software GLIMMER. The molecular study is complete and the field experiment for indigenous isolates testing for competitiveness is ongoing.

Table1: Details on primers used for genetic diversity

Primer	Sequence	Target region	gene function
16S rRNA genes			
27F	AGAGTTTGATCMTGGCTCAG	16S	Conserved region of bacteria
1492 R	GGTTACCTTGTTACGACTT	16S	Conserved region of bacteria
Housekeeping genes			
glnII-1F	AACGCAGATCAAGGAATTCG	glnII	glutamine synthetase
glnII-2R	ATGCCCGAGCCGTTCCAGTC	glnII	glutamine synthetase
glnII12F	YAAGTTCGAGTACATYTGGC	glnII	glutamine synthetase
glnII689R	TGCATGCCSGAGCCGTTC	glnII	glutamine synthetase
atpD273 F	SCTGGGSCGYATCMTGAACG	atpD	ATP synthetase
atpD273 R	GCCGACACTTCMGAACCNGC	atpD	ATP synthetase
recA6F	CGKCTSGTAGAGGAYAAATC	recA	DNA recombination and reparation
recA504R	TTGCGCAGCGCCTGGCTCAT	recA	DNA recombination and reparation
Symbiotic genes			
nodA-1 F	TGCRGTGGAARNTRNNCTGG	nodA	Acyl chain transferase
nodA-2 R	GGNCCGTCRTCRAAWGTCAR	nodA	Acyl chain transferase
nifH- F	TACGGNAARGGSGGNATCGGCAA	nifH	encodes enzymes involved in the N fixation
nifH- R	AGACATGTCYTCSAGYTCNTCCA	nifH	encodes enzymes involved in the N fixation

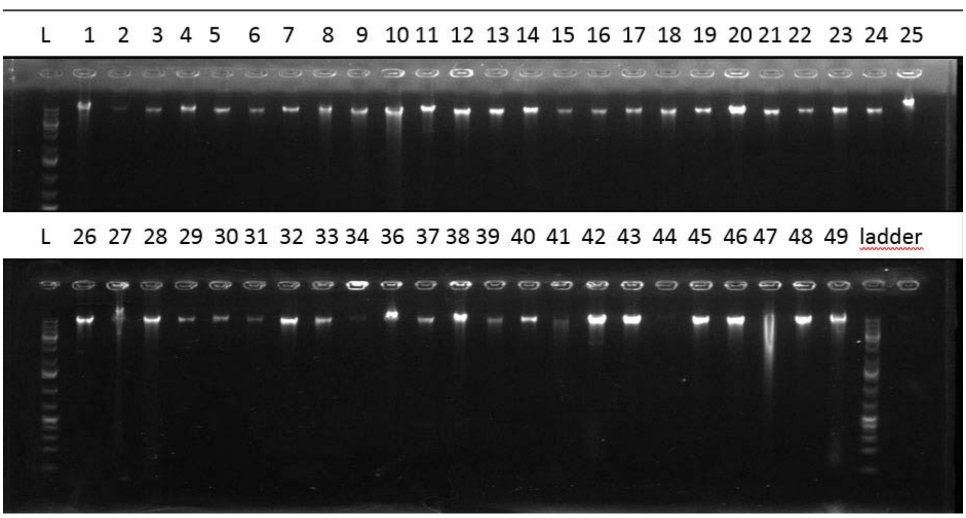


Figure 1: Genomics for DNA detection in NAC isolates from NAC1 to 49

DNA was extracted from indigenous rhizobia cultures (NAC) obtained from IITA-Kalamo Rhizobiology laboratory. DNA was extracted by QI GEN extraction kit following manufacturer's instructions.

The presence, the absence, the quantity and quality of DNA was assessed using nanodrop method and electrophoresis. The concentration of DNA in samples varied between 20 and 130 ng/µl as indicated in the table 1. The presence of DNA was notified in the majority of samples as indicated on the figure 1.

Bintu Nabintu Ndusha, University of Nairobi, Kenya (No previous updates)

Assessment of the impact of improved cowpea varieties on women farmers in southern part of Borno State, Nigeria

I examined the impact of improved cowpea technology on women farmers which was introduced by the Promoting Sustainable Agriculture in Borno State, (PROSAB), project which was implemented from 2004 to 2009 in Southern Part of Borno State, Nigeria. The specific objectives were to identify the changes in income as a result of using improved cowpea varieties by the respondents, analyze the impact of the improved technology on the food security status of the respondents and identify the constraints associated with the use of improved cowpea varieties. Both primary and secondary data were used for the study. The primary data were collected by use of structured questionnaires administered to 240 farmers who participated in the PROSAB project and also planted the improved cowpea introduced (participants) and 60 farmers who did not (non-participants) to give a total of 300 respondents who were selected using a random sampling technique. The secondary data used include data from the baseline survey conducted when the PROSAB project was implemented in 2004.The Double Difference (DD), the Cost-of-calorie index and descriptive statistics were the analytical tools used to analyse the data collected. The DD is the difference between the income of both the participants and non-participants before implementation of the PROSAB project (2004) and after project has ended (the project ended in 2005 and this study was conducted in 2015).

The results showed that there was a positive impact on income as a result of using the improved cowpea varieties (Table 1). The annual income of the participants increased by ₦143, 495.20 ($724.72) which was higher than that of the non-participants which increased by only ₦58, 500.00 ($295.45). The increase in the non-participant's income was as a result of spill-down effect from those that adopted the improved cowpea technology.

The results showed that the food insecurity line, Z, which is the cost of the minimum energy requirements per adult equivalent, was determined as ₦1,975.01 per month before PROSAB. This was based on the daily energy level of 2250 kcal recommended by FAO (2009).With a head count of 0.58, it indicates that 58% of households were food insecure while 42% were food secure. The aggregate income gap (G) of -375.74 indicates that ₦375.74 was the amount needed by the food insecure households to meet their basic food needs (Table 2).

Table 1: Average Household Income (N) from Cowpea Before (2004) and After (2015) the PROSAB Project

	Before PROSAB (₦)	After PROSAB (₦)	Difference (₦)	Percentage Difference (%)	Double Difference (DD) (₦)	T-Value
Participants	56,004.80	199,500.00	143,495.20	256.20	**84,995.20**	8.43***
Non-Participants	31,000.00	89,500.00	58,500.00	188.70		

Source: Field Survey Data (by me), 2015.
Note: *** significant 1%

Table 2: Food Security Measures among Women in Southern Borno State

Variable	Before PROSAB	After PROSAB Participants	Non-Participants	DD
Cost-of-calorie equation	lnX=a + bC	lnX=a + bC	lnX=a + bC	
Constant	4.154	4.4510	3.2506	
	(0.534)*	(60.972)*	(21.963)*	
Slope coefficient	0.0019	0.0000144	0.0004221	
	(0.0004)	(12.496)	(16.234)	
FAO recommended daily energy Levels (L)	2260 kcal	2260 kcal	2260 kcal	
Food insecurity line (Z)	₦ 63.71 per day	₦88.51 per day	₦66.99 per day	₦21.52
	₦1,975.01 per month	₦2,743.81 per month	₦2,076.69 per month	₦667.12
Head Count (H)	0.58	0.3433	0.673	-0.3297
Percentage Food Insecure	58%	34%	67%	-33%
Percentage Food Secure	42%	66%	33%	33
Aggregate income gap (G)	-375.74	-412.43	-783.91	371.48

Source: Field Survey Data (by me)0, 2015.* Figures in parenthesis are t-value

The results of this study showed that the food insecurity line for the participants was ₦2,743.81 per month after PROSAB. The results also showed that the food insecure among the participants were 34% while 66% were food secure. The aggregate income gap was -412.43 implying that they need ₦412.23 to meet their basic food needs. This implies that food insecurity among the participants could have been reduced as a result of the PROSAB intervention. In the case of the non-participants, their food insecurity line was ₦2,076.69 per month after PROSAB. Only about 33% were food secured and 63% were food insecure and require additional ₦783.91 to meet their basic food needs. The DD indicates a positive difference of ₦667.12 between the participants and non-participants. This shows that the improved cowpea technology has had an impact on food security of the respondents.

The women cowpea farmers were constrained by various factors like diseases and pests, high cost of labour, inad-

Table 3: Constraints Faced by Women Farmers in Improved cowpea Production.

	Participants		Non-participants	
Constraint	**Frequency**	**Percentage** (%)	**Frequency**	**Percentage** (%)
Inadequate Seeds	29	12	54	90
High cost of seeds	17	7	46	76
Inadequate access to market	60	25	52	87
Inadequate extension visits	38	16	56	93
Inadequate of fertilizer	24	10	41	68
Tenure problem	38	16	7	12
High cost of labour	84	35	8	13
Diseases and pests	209	87	59	98
Low yield	34	14	46	76
Inadequate information on improved seed	5	2	58	97
Drought	31	13	39	65

Source: Computed from Field Survey Data (by me), 2015.

equate seeds, inadequate information and inadequate access to markets (Table 3).

I recommend that policies should be formulated to encourage women farmers in the study area to adopt and sustain the use of improved varieties of cowpea. Improved cowpea varieties and other inputs should be made readily available and accessible to the women farmers at affordable prices, on time and in adequate quantities. The women farmers in the study area should be given adequate enlightenment on how to control pests and diseases. The women farmers' access to extension services and and number of contacts with extension agents should be increased especially for the non-participants.

Binta Ali Zongoma, Department of Agricultural Economics, University of Maiduguri, Maiduguri, Borno State. Nigeria
(Click here for her 2017 update)

Phylogenetic multilocus sequence analysis of indigenous Rhizobia nodulating cowpea in Nigeria

The promiscuity ability of cowpea enables it to form nitrogen-fixing root nodules with diverse symbiotic bacteria. It is mainly nodulated by slow-growing bacteria which constitute heterogeneous group of rhizobia called "cowpea miscellany" belonging to the genus Bradyrhizobium. Currently the genus Bradyrhizobium comprises forty-one type strains (http://www.bacterio.cict.fr/) while type strains isolated from other hosts such as *Bradyrhizobium daqingense, Bradyrhizobium huanghuaihaiense, Bradyrhizobium paxllaeri, Bradyrhizobium ottawaense, Bradyrhizobium yuanmingense* are also capable of nodulating cowpea. In order to gain insight into the genetic diversity of indigenous rhizobia isolated from nodule trapped from soil collected from three different geographical regions (Niger, Kaduna, Kano) in Nigeria, a detailed multilocus sequence analysis of concatemers of two protein-coding genes (glnll-recA) was performed.

The DNA fragments of the following loci were amplified with their respective primers using pure single colony of rhizobia strains diluted in sterile water and amplified by polymerase chain reaction with primers TSglnllF&TSglnllR for glnll-gluthamine synthetase II and TSrecAF&TSrecAR for recA-DNA recombination protein. The partial gene sequences obtained together with sequences retrieved from GenBank were aligned using the CLUSTAL W software in the MEGA 7.0 software package. Phylogenetic trees were constructed using the neighbour-joining (NJ) methods in MEGA 7.0 software package. The gene sequences were concatenated using R software.

Bradyrhizobium species are divided into well-supported phylogenetic lineages designated I (represented by *Bradyrhizobium japonicum*) and II (represented by *Bradyrhizobium elkanii*) based on phylogenetic analyses of rrs gene and 16S-23S rRNA IGS. All strains included in this study clearly seperate into the two different groups as shown in Figure 1 below. The phylogenetic analysis based on the concatenated sequences is more robust and confident. Within the *Bradyrhizobium elkanii* group, strains **CNW 20d**, **CNW 38c** clustered with *Bradyrhizobium elkanii*, while **ten** of the strains clustered with *Bradyrhizobium pachyrhizi.* Within the *Bradyrhizobium japonicum* group, **CNW 17o** clustered with *Bradyrhizobium yuanmingense*, **CNW 4bN, CNW 1a**, **CNW 27f**, **CNW 36a** clustered with *Bradyrhizobium diazoefficiens*, **CNW 50c** clustered with *Bradyrhizobium kavangense*. Based on pairwise comparisons of the two concatenated sequences, the isolates **CNW 4bN**, **CNW 1a**, **CNW 27f**, **CNW 36a** displayed sequence similarities to **USDA 110^T, 99.1%, 100%, 100%, 100%** respectively. C**NW 20d**, **CNW 38c** showed sequence similarity with to **USDA 76^T, 99.5%, 99.5%** respectively. All the strains that clustered with **PAC 48^T** showed sequence similarity of 99.1%.

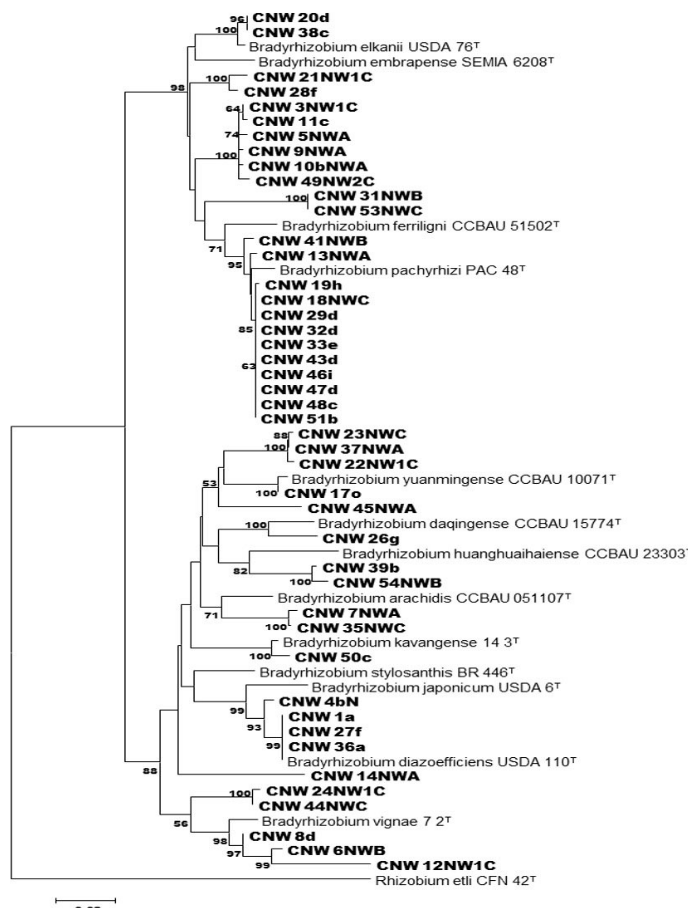


Figure 1. Neighbour-joining phylogenetic tree based on 751 bp concatenated sequence of glnII and recA showing taxonomic relationships of the strains. Strains isolated in the present study are shown in boldface and type strains are indicated by superscript "T". Bootstrap values (greater than 50%) were calculated for 1000 replications and are shown at the nodes. The scale bar shows the number of nucleotide substitutions per site. Phylogenetic analysis was conducted in MEGA 7 using the neighbour-joining algorithm with the Kimura 2-parameter model plus Gamma Distributed (G).

The close phylogenetic relationships with strains used as inoculants render them worthy for further investigation as inoculants in fields with similar edapho-climatic conditions. Therefore, studies investigating indigenous rhizobia in fields without rhizobia inoculation history are of importance for selecting novel strains adapted to the local environmental conditions. Future studies on symbiotic properties are needed to demonstrate whether they represent novel symbiovars.

Ojo Comfort Tinuade, Wageningen University & Research, The Netherlands (Click here for her 2017 update)

The effects of rhizobial inoculation, phosphorus application and cowpea-cowpea sequential cropping system on some varieties of cowpea on farmers' fields in Minna, southern Guinea savanna of Nigeria

The trials conducted in 2016 were repeated in 2017 to determine the effects of phosphorus fertilizer application and rhizobial inoculation on photosynthetic efficiency, nodulation, growth and productivity of three cowpea varieties and secondly to evaluate the performance of some varieties of cowpea in cowpea-cowpea sequential cropping system on three farmers' fields in Minna, southern Guinea savanna of Nigeria.

The treatments of the first trial included three phosphorus rates (0, 20 and 40 kg P ha^{-1}), five nitrogen sources (uninoculated, application of 90 kg N ha^{-1}, inoculation with BR 3262, BR 3267 and USDA 3451 rhizobial strain) and three cowpea varieties (IT99K-573-1-1, IT93K-452-1 and TVX 3236). These were factorially combined and laid out in a randomized complete block design. The treatments of the second trial included six varieties of cowpea viz: IT93K-452-1, IT90K-76, Oloyin, IT99K-573-1-1, TVX-3236 and Kanannado planted in two sequence.

The results revealed that:

- Phosphorus fertilizer application significantly increased the quantum yield of photosystem II (photosynthetic efficiency), growth, nodulation and yield of the three cowpea varieties used. Plants without P-fertilizer consistently gave the lowest values in all the parameters measured and the values obtained in plants that received 20 and 40 kg P ha^{-1} were at par except for grain yield (Figure 1)
- Variety IT99K-573-1-1 and IT93K-452-1 plants had similar performance in biomass yield and nodule weight which was significantly higher than the values recorded in TVX 3236. However, IT99K-573-1-1 plants produced significantly higher grain yield than the remaining two varieties.

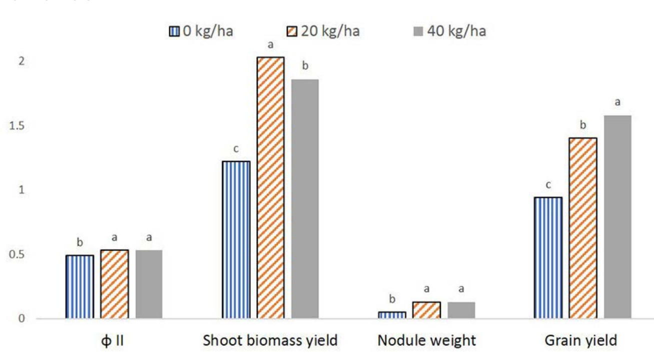


Figure 1: Effect of phosphorus application on the performance of cowpea

- There was no significant difference among the inoculated, 90 kg N ha^{-1} fertilized and uninoculated plants with respect to photosynthetic efficiency and grain yield. However, plants fertilized with 90 kg N ha^{-1} had significantly higher shoot biomass yield than the inoculated plants (Figure 2).

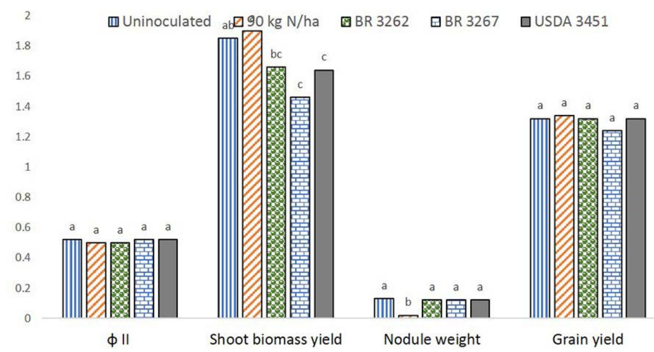


Figure 2: Effect of rhizobial inoculation on the performance of cowpea

- Interaction effect of rhizobial inoculation and phosphorus application on nodule number revealed that plants inoculated with BR 3262 required more phosphorus than others for maximum nodulation (Figure 3).

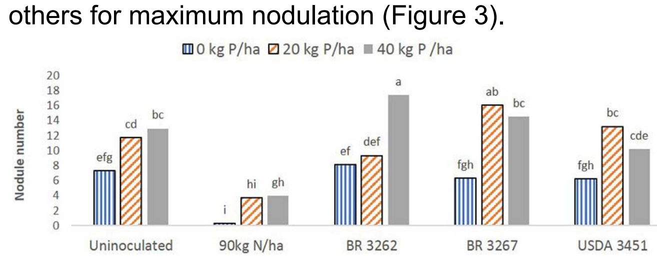


Figure 3: Interaction effect of rhizobial inoculation and phosphorus application on nodule number of cowpea

The result of the second trial revealed that:

- All the varieties were successfully planted twice in a season except Kanannado in which only one sequence was achieved (Figure 4).

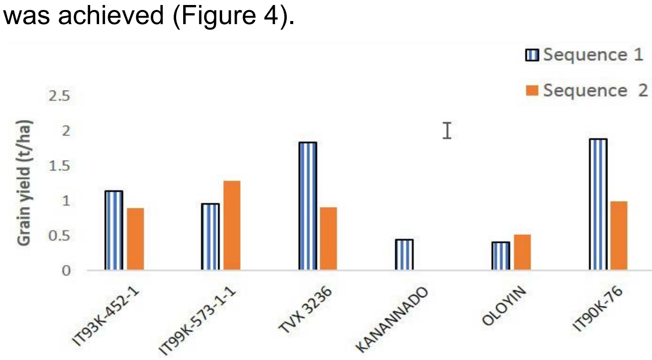


Figure 4: Grain yield of some cowpea varieties planted in sequence

- Of the five varieties that were planted twice IT90K-76 had the highest cumulative yield, closely followed by TVX 3236. The least was recorded in oloyin variety.

Conclusion

1. P application is important for optimum performance of cowpea in the study area.
2. The symbiotic effectiveness of the rhizobial inoculants used was not better than the indigenous strain present in the study area.
3. IT99K-573-1-1 performed relatively better in grain yield than the other two varieties used.
4. TVX 3236 and IT90K-76 are the best cowpea varieties among those tested for early planting in the study area.
5. IT90K-76, TVX 3236, IT99K-573-1-1 and IT93K-452-1 can be recommended for cultivation in cowpea-cowpea sequential cropping system in the study area.

Adediran Olaotan Abimbola, Federal University of Technology, Minna, Nigeria (Click here for her 2017 update)

Phylogeny of rhizobia nodulating common bean (*Phaseolus vulgaris* L.) in Ethiopia

Introduction

Common bean (*Phaseolus vulgaris* L.) is an important food legume and is a main source of protein, hence its nickname 'poor man's meat' (Broughton et al. 2003). It plays a vital role in agriculture by associating with rhizobia and fixing atmospheric N_2 through a biological nitrogen fixation (BNF) process. A wide range of rhizobia is known to associate with beans due to its promiscuous nature and these different strains are likely to vary in their BNF potential. Thus, with the aim of identifying more effective rhizobia, we trapped new strains from bean growing areas in Southern Ethiopia and genotyped them to determine their taxonomic identity and relatedness to reference strains of known N_2 fixing ability.

Materials and Methods

Phaseolus vulgaris nodulating rhizobial strains were trapped from soil using *Nasir*, *Ebado* and *Hawassa dume* bean varieties. The strains were amplified using colony PCR for symbiotic (*nodC* and *nifH*), housekeeping (*glnII*, *gyrB*, *recA* and *rpoB*) and 16S ribosomal RNA genes. Cleaned PCR products were sequenced by Macrogen Inc. The Netherlands. The quality of the DNA sequences were checked by BioEdit package and blasted to sequences in Gene bank using nucleotide blast method in NCBI. The sequences were then aligned by ClustalW in MEGA7 (Thompson et al. 1994) and a Neighbour-joining phylogenetic tree was constructed based on a pairwise distance matrix using Tamura's 3-parameter substitution model with complete deletion of gaps. Robustness of the tree topology was evaluated using 1000 boot strap iterations (Kumar et al. 2016). Here, we present a phylogeny of concatenated loci (*glnII*, *gyrB* and *recA*).

Results and Discussion

The evolutionary phylogeny based on multilocus sequence analysis (MLSA) grouped the new strains into VI clusters and mostly with *Rhizobium etli* (CFN42), *R. phaseoli* (ATCC14482), *R. aethiopicum* (HBR26) and *R. etli* bv. *phaseoli* (IE4803) type strains, cluster I-V (Fig. 1). Strains (NAK91 and NAK103) originated from Kenya and one of our new isolate NAE165 clustered (cluster VI) with *R. tropici* (CIAT899) commercial strain at 100% boot strap of nucleotide similarity. In a previous study using 16S rRNA and

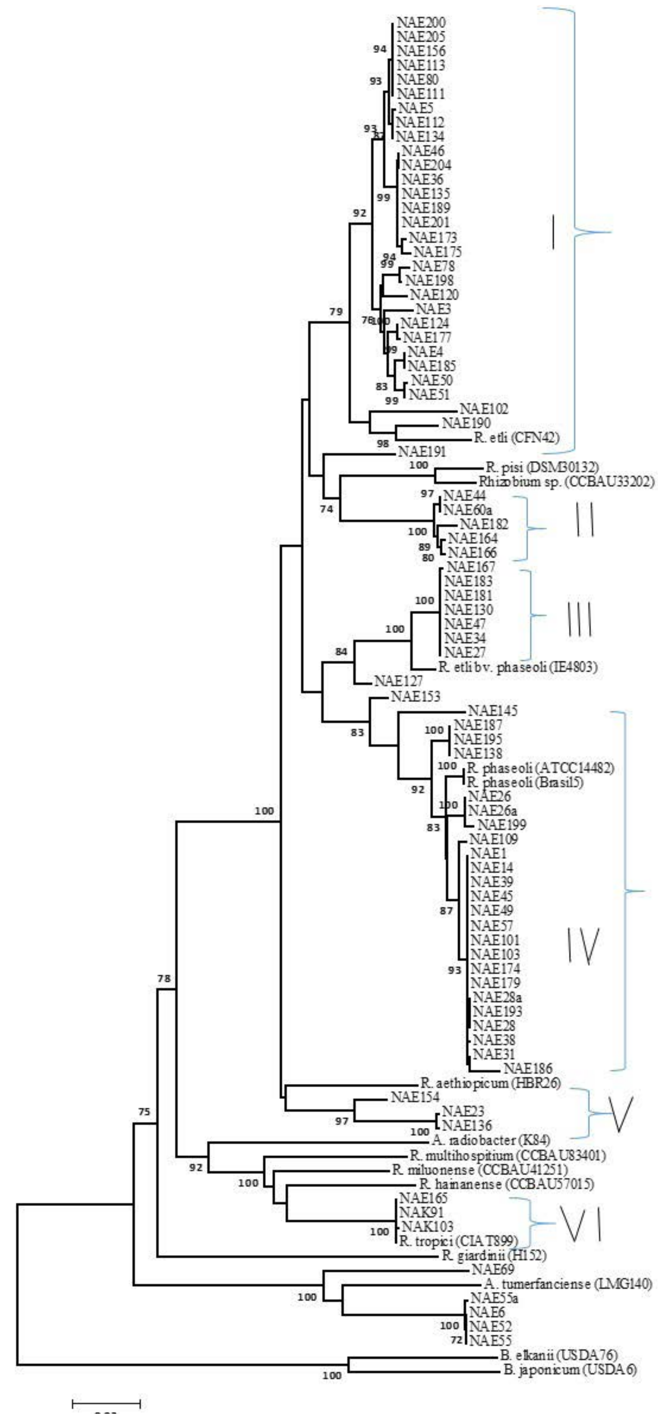


Figure 1: Neighbour-joining phylogeny of MLSA

concatenated *recA* and *atpD* genes, NAK103 was grouped with *R. phaseoli* (ATCC14482) (Mwenda et al. 2018). This difference might be due to mislabelling during sharing the strains or due to differences in resolution capacity of the loci used. A few new isolates such NAE6, NAE55, etc. clustered with *Agrobacterium radiobacter* (LMG140).

Conclusions

Our new Ethiopian isolates are mostly related to *R. etli* and *R. phaseoli* groups. Strains in cluster II may be a new genospecies and need to be further investigated.

Ashenafi Hailu Gunnabo, Wageningen University & Research, The Netherlands (Click here for his 2017 update)

References

10.1016/j.syapm.2011.11.005

Broughton WJ, Hernandez G, Blair M, et al (2003) Beans (Phaseolus spp.) - model food legumes W. Plant Soil 252:55–128. doi: 10.1023/A:1024146710611

Kumar S, Stecher G, Tamura K (2016) MEGA7: Molecular Evolutionary Genetics Analysis Version 7.0 for Bigger Datasets. Mol Evol Genet Anal 33:1870–1874. doi: 10.1093/molbev/msw054

Mwenda GM, O'Hara GW, De Meyer SE, et al (2018) Genetic diversity and symbiotic effectiveness of Phaseolus vulgaris -nodulating rhizobia in Kenya. Syst Appl Microbiol. doi: 10.1016/j.syapm.2018.02.001

Thompson JD, Higgins DG, Gibson TJ (1994) CLUSTAL W: Improving the sensitivity of progressive multiple sequence alignment through sequence weighting, position-specific gap penalties and weight matrix choice. Nucleic Acids Res 22:4673–4680. doi: 10.1093/nar/22.22.4673

Understanding the influence of barriers on smallholders' perception and adoption of legume technologies in Ethiopia: A qualitative study

Studies on adoption of new products, services and technologies by smallholders mainly look into barriers affecting adoption and application of Rogers' innovation adoption theory (Rogers, 1983). Following the case study research methodology, I studied qualitatively the interaction between adoption barriers and smallholders' perceptions to develop a detailed understanding on how different barriers have an impact on different adoption perceptions following Rogers' adoption theory and thereby know smallholders' decision to adopt. N2Africa facilitated Public-Private Partnership (PPP) cases are analysed based on four main research questions. These include, (a) how do smallholders perceive the value propositions, (b) what are the potential adoption barriers, (c) how do the barriers influence smallholders' perceptions, and (d) adoption decisions in the different case studies. Multiple interview protocols used to make interviews with multiple actors in each case study.

From the analysis of key informant interviews – conducted with 13 lead farmers, 5 research partner centres, 12 opinion leaders, 4 private input suppliers, 6 farmers' primary cooperatives and 6 farmers' cooperative unions it is understood that smallholders' perception of the relative advantage of the improved legume seeds as compared to local and/or other varieties are highlighted through enhancements in perceived productivity, marketability and resistance to plant diseases and pests. The high-level abstraction of perceptions, in turn, are described using low level product attributes, for example, grain and biomass yield to explain the perceived productivity and colour and seed size to explain the perceived marketability (see Table below).

From the interviews it is understood that adoption barriers influence smallholders' perception of improved legume seeds and hence farmers' decision to buy (adoption decision). The 'high seed price' is an adoption barrier. Farmers tend to use seeds from their own storage for subsequent years, and not from seed supplied by the cooperative. Likewise, the adoption barriers chickpea diseases (rust) and pests (bollworm) influence the variety's perceived resistance to diseases and pests (relative advantage). Dinku Feyisa, a lead farmer who participated on improved chickpea seed promotion in Gimbichu *Woreda* Adadi Gole Kelebe said the following supporting the interrelation between adoption barriers, perception and adoption decisions;

"Arerti variety is preferable at market, is high yielder, resistant to rust, residues (leaves and haulms-stems are strong) used as animal feed and is highly demanded by farmers. However, because seed price is high, and the variety is affected by bollworm, most farmers keep using the improved seed from own storage".

The perceived productivity and resistance to diseases of improved legume seeds (perceived relative advantage), however, varies between the key informants which may also represent perception differences among the broader smallholders. On the other hand, the perceived marketability (perceived relative advantage) and affordability (perceived uncertainty) of the improved legume seed varieties seem to be consistent. For example, farmer Tamiru Yami who participated on chickpea dissemination had an opposing view to farmer Dinku Feyisa's perceived productivity and resistance to disease of the same variety;

"The variety (Arerti) is susceptible to rust, so half part of the plant didn't fill grains; no other varieties are affected like this. But the variety has good market preference, better seed size (medium). High seed price of the variety made it difficult to buy from the cooperative. Farmers source the variety from local market but not from seed supplying cooperatives".

Table: Smallholders' perceptions, adoption barriers and purchase decisions of legume technologies productivity enhancing value propositions

Offered legume technologies	Legume technology perceptions		Adoption barriers	Adoption decision (intention/behavior)
	High level abstraction of perceptions	**Low level perceptions (product/service attributes)**		
Improved legume seeds	Productivity	High grain and biomass yield, more branches and seeds per pod, and no sterile pods	• High seed price • Lack of timely seed supply (access) • High rainfall variability • Lack of mechanization service (planters and threshers) for legumes • Lack of new seed varieties (basic and certified) • Less commitment from unions in serving member farmers need • Non-dynamic chickpea grain price (price integration) • Poor consumers awareness (attitude) on legume-based food diversity • Poor output market linkage • Disease and pests	• Intend to use next year • Keep using but from own stored, seed purchase depends on availability of buyer • Not using this year due to land shortage, allotted land for sorghum and teff • Keep using after dissemination, can be formally or informally accessed • Intend to use • Keep using after dissemination, can be formally or informally accessed
	Market preference	Marketable (bigger seed size), good grain quality for market, bigger seed sizes and white color		
	Resistance to disease (pests)	Resistant to diseases and/pest, susceptible to disease		
	Resistance to moisture stress	Early maturing and escapes moisture stress, late maturing and susceptible to moisture stress		
	Multifunctionality	Improved seed can counter act multiple barriers of disease and moisture stress		
	Uncertainty about product performance	Hesitation about the sustainability of technology performance		
	Susceptibility to green pod consumption (chickpea)	Improved chickpea seeds are bigger in size, but susceptible to human pest, so farmers may refrain from using(barrier-perception)		
Inoculant	Affordability	Cheap, could be used sustainably	• Low awareness on inoculant use, low promotion • Limitation in supply (access) • Non-responsiveness on some legumes (chickpea in North and soyabean in Chewaka cases)	• Intend to use • Keep using after dissemination next to improved seeds
	Productivity	High yield and hence high farmer demand, low yield due to low response in some of the cases (Difficult to adopt).		
	Resistance to disease (pests)	Prevent soil borne diseases?		
	Soil fertility improvement	Enhanced soil fertility		
	Uncertainty about product performance	Hesitation about the sustainability of technology performance		
P-fertilizer	Affordability	High price	• High price of p-fertilizer, lack of capacity to buy • Wrong farmers' view that p-fertilizer application makes the plot unproductive afterwards	• Not willing to apply for legumes
	Importance/relevance	Farmers think legumes can at least yield without p-fertilizer, assumed not a priority for legumes, impact is marginal increment as compared to seed		
	Product uncertainty	Destroy soil fertility once applied, no yield without p-fertilizer application afterwards		
Row planting	Convenience (ease of use)	Difficult to practice,	• Labour shortage (both human and ox)	• Intend to use
	Labour intensiveness	More ox labour requirement, competition with other enterprises		
Weeding	Importance/relevance	Trade-off, removing weeds cause animal feed shortage	• Lack of herbicides (soyabean) • Labour shortage	
		Weeding is intensive (soyabean) as compared to maize (herbicide for maize)		

My next study will build on the findings of this qualitative study, and quantitatively measure the influence of adoption barriers on smallholders' perception of the value propositions and consequently their intention to adopt technologies. In doing so I will identify the main barriers that influence smallholders' adoption intentions.

Tamiru Amanu, International Livestock Research Institute, Ethiopia and Wageningen University & Research, the Netherlands (Click here for his 2017 update)

Perceptions of livestock traders and fatteners on the use of grain legume residues in northern Ghana

Grain legume residues (GLRs) are among the main feed resources used by livestock producers in northern Ghana, especially during the dry season. GLRs are preferred to cereal residues as livestock feed because of their relatively higher nutrient levels. They are extensively used among major livestock production chain actors such as smallholder farmers, fatteners and trader. Opportunities for increasing livestock production and trade in northern Ghana strongly depend on the availability and accessibility of feed resources, such as the supply of GLRs by farmers.

A survey was conducted in the three regions of northern Ghana to study the perception on grain legume residues use as livestock feed among livestock traders, fatteners and those who were involved in both activities. The study was conducted in Savelugu/Nanton, Nadowli and Binduri districts of Northern, Upper West and Upper East regions respectively.

Results indicated that 70% of the respondents strongly agreed that GLRs are good sources of animal feed. However, about 40% disagree that GRLs are cheap sources of feed for their animals (Table 1). After collectively grouping the perceptions into good and poor perceptions of GLRs, about 53% of respondents have a good perception about GLRs while 47% have a bad perception. We also found that some demographic characteristics such as respondents' educational levels and location have a significant impact on their perception of GLRs. Traders and fatteners with some form of formal educated tend to have a good perception about GLRs than non-educated ones (Table 2). Respondents in Upper East region had a better perception about GLRs compared to other regions (Table 2). These findings reflect the real situation in the regions because GLRs use as livestock feed is more prevalence in the Upper East region as compared to the other two region. The high demand for GLRs in the Upper East region had led to the emergence of many feed markets in the region.

Table 2: Demographic characteristics associated with perception on the use of grain legume residues.

Demographic variable	Perception on the use of GLRs			Pearson chi-square	
	Poor=63 n(%)	Good=70 n(%)	Total=133 n(%)	χ2	p-value
Age group					
<30	4(6.3)	3(4.3)	7(5.3)	3.986	0.24
30-39	12(19.0)	24(34.3)	36(27.1)		
40-49	42(66.7)	38(54.3)	80(60.2)		
60+	5(7.9)	5(7.1)	10(7.5)		
Marital status					
Single	2(3.2)	4(4.5)	5(3.9)	1.03	0.60
Married	61(96.8)	66(94.3)	127(95.5)		
Education					
None	42(66.7)	28(40.0)	70(52.6)	9.89	0.02
Primary	8(12.7)	16(22.9)	24(18.1)		
Junior	7(11.1)	17(24.3)	24(18.1)		
Senior/tertiary	6(9.5)	9(12.8)	15(11.2)		
Region					
Northern	33(52.4)	22(31.4)	55(41.4)	16.34	0.00
Upper east	27(42.9)	26(37.1)	53(39.8)		
Upper west	3(4.8)	22(31.4)	25(18.8)		
Profession					
Fattener	18(28.6)	26(37.1)	44(33.1)	1.85	0.40
Trader	30(47.6)	33(47.1)	63(47.4)		
Both	15(23.8)	11(15.7)	26(19.5)		

Table 1: Frequency of perception among livestock traders and fatteners about the statement on grain legume residues (GLRs)

Perception statement	**Response**					
	Strongly disagree	**Disagree**	**Neutral**	**Agree**	**Strongly agree**	**Total**
	n(%)	**n(%)**	**n(%)**	**n(%)**	**n(%)**	**N**
GLRs are a good source of animal feed	-	3.1	4(3.1)	35(26.7)	92(70.2)	131
GLRs are a cheap source of feed for my animals	8(6.1)	52(39.7)	21(16.0)	30(22.9)	20(15.3)	131
Animals perform better when fed with GLRs than other feed sources	3(2.3)	17(13.0)	23(17.6)	41(31.3)	47(35.9)	131
I preferably use GLRs as livestock feed compared to concentrates	7(5.4)	14(10.8)	22(16.9)	51(39.2)	36(27.7)	130
GLRs are more easily accessible than concentrates	5(3.8)	34(26.2)	20(15.4)	32(24.6)	39(30.0)	130
GLRs are only available in the dry season	15(11.5)	28(21.5)	21(16.2)	42(32.3)	24(18.5)	130
GLRs are only useful in the dry season	29(22.5)	31(24.0)	22(17.1)	27(20.9)	20(15.5)	129
GLRs cannot be stored for more than 5 months	36(27.9)	53(41.1)	20(15.5)	12(9.3)	8(6.2)	129
I have increased the use of GLRs as livestock feed over the past ten years	18(14.1)	14(10.9)	10(7.8)	47(36.7)	39(30.5)	128

Daniel Brain Akakpo, Wageningen University & Research, The Netherlands (Click here for his 2017 update)

Legume-maize rotation or relay? Options for ecological intensification of smallholder farms in the Guinea savanna of northern Ghana

In my last update, I presented portion of my second paper published in Field Crops Research (https://authors.elsevier.com/sd/article/S037842901730727X).

In this Podcaster, I present a short summary of my third paper recently published in Experimental Agriculture: Kermah, M., Franke, A.C., Ahiabor, B.D.K., Adjei-Nsiah, S., Abaidoo, R.C., & Giller, K.E., (2018). Legume-maize rotation or relay? Options for ecological intensification of smallholder farms in the Guinea savanna of northern Ghana. *Experimental Agriculture*, 1–19. https://doi.org/10.1017/S0014479718000273

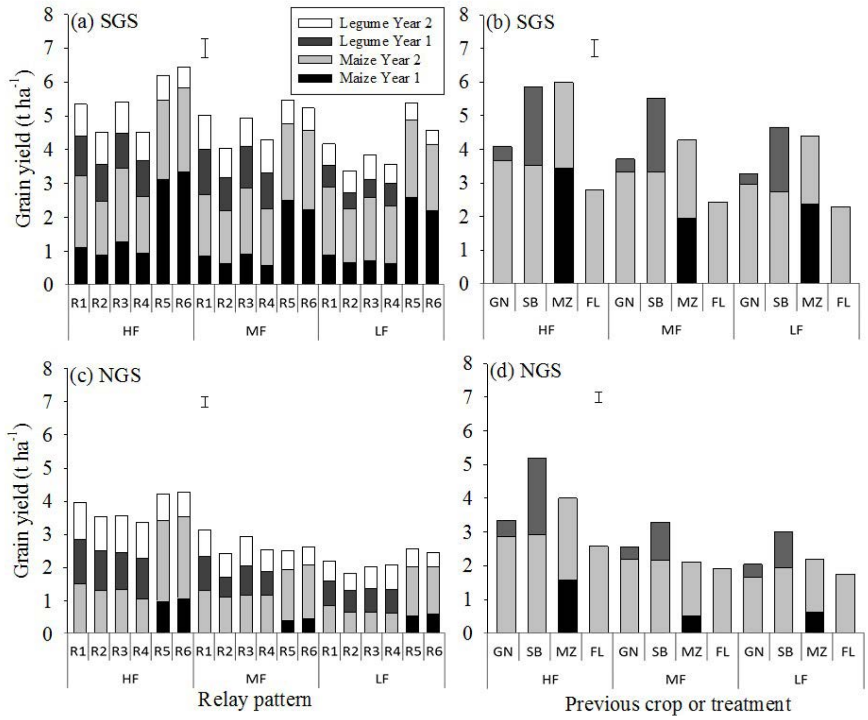


Fig. 1. Maize and legume grain yields as influenced by different relay and rotation cropping sequences and soil fertility status in both years in southern Guinea savanna (SGS) and northern Guinea savanna (NGS). Error bars indicate the combined standard error of differences between means for the different cropping patterns across soil fertility status.

Note:
R1 = cowpea sown first, maize sown later at 3 (Year 1) and 2 weeks (Year 2) in 2:1 stands
R2 = cowpea sown first, maize sown later at 6 (Year 1) and 4 (Year 2) weeks in 2:1 stands
R3 = cowpea sown first, maize sown later at 3 (Year 1) and 2 weeks (Year 2) in 1:1 stands
R4 = cowpea sown first, maize sown later at 6 (Year 1) and 4 (Year 2) weeks in 1:1 stands
R5 = maize sown first, cowpea sown later at 6 (Year 1) and 3 (Year 2) weeks in 1:2 stands
R5 = maize sown first, cowpea sown later at 9 (Year 1) and 5 (Year 2) weeks in 1:2 stands
GN = groundnut; SB = Soybean; MZ = maize; FL = natural fallow

The increasing demand for food associated with the growing population in West Africa necessitate the intensification of crop production. Legume-cereal rotation have thus dominated the smallholder farming systems due to the increased yields of maize following legumes relative to continuous sole cropping of maize. Hence, many studies in the region have largely concentrated on sole crop legume-maize rotations. However, the erratic rainfall pattern in the Guinea savanna presents a risk of possible crop failure in sole cropping that can extremely threaten household food, nutrition and income given that the area has only one cropping season a year. Crop diversification and intensification system that retain the recommended planting density of sole maize with a grain legume added may provide food in case of poor rainfall and failure of the maize. This study explored a diversity of short duration cowpea and maize relay cropping systems that could contribute to mitigating risks of crop failure in sole cropping and increase food production. These were compared with continuous maize and rotations of soybean, groundnut and fallow with maize in farmers' fields differing in soil fertility in the southern and northern Guinea savanna agro-ecological zones of northern Ghana.

Sowing maize first with cowpea sown at least 3 weeks after sowing (WAS) the maize led to a 0.18–0.26 t ha^{-1} reduction in cowpea grain yield compared with cowpea sown from the beginning (Fig. 1). Sowing cowpea first followed by maize sown at least 2 WAS the cowpea resulted in a 0.29–0.82 t ha^{-1} reduction in maize grain yield relative to maize sown from the onset due to less rainfall received by the relay maize (Fig. 1). Groundnut and soybean induced 0.38–1.01 t ha^{-1} more grain yield of a subsequent maize than a continuous maize, and 1.17–1.71 t ha^{-1} more grain yield than the relay systems (Fig. 1). The results indicate that a rotation of soybean or groundnut with maize is superior in increasing subsequent maize yield than relay cropping of maize and cowpea, and a maize succeeding a natural fallow in rotation. However, accumulated crop yields over two years were comparable between soybean-maize rotation and the relay system where maize was sown first followed by a cowpea, while that relay system was more productive than the other cropping systems (Fig. 1). This indicate that sowing maize first and cowpea relayed into it is a promising ecological intensification option alternative to the more common legume-maize rotation in the Guinea savanna and recommended when the growing season is short due to late onset of rainfall.

Michael Kermah, Wageningen University & Research, The Netherlands (Click here for his 2017 update)

Grain legumes within a healthy Ghanaian diet

Recently, we submitted a paper to the Nutrition Journal on the current and potential role of grain legumes on protein (both quantity and quality) and micronutrient adequacy of the diet of rural Ghanaian infants and young children. We collected dietary intake data with repeated quantitative multi-pass 24-hour recall method to assess energy and nutrient (including amino acids) intakes of breastfed children of 6-8 months (*n*=97), 9-11 months (*n*=97), 12-23 months (*n*=114), and non-breastfed children of 12-23 months (*n*=29) from Karaga district in Northern Ghana. Food-based dietary guidelines that best cover nutrient adequacy within the constraints of local current dietary patterns were designed using the linear modelling programme Optifood. Optifood was also used to evaluate whether additional legumes would further improve nutrient adequacy. We found that 40% of the children currently consumed legumes with an average portion size of 20 g per day contributing more than 10% of their total protein, folate, iron and niacin intake. The final best sets of food-based recommendations included legumes and provided adequate protein and essential amino acids but insufficient calcium, iron, niacin and/or zinc among breastfed children and insufficient calcium, vitamin C, vitamin B12 and vitamin A among non-breastfed children. The sets of food-based recommendations combined with extra legumes on top of the current dietary pattern improved adequacy of calcium, iron, niacin and zinc but only reached sufficient amounts for calcium among breastfed children of 6-8 months old. Thus although legumes are often said to be the 'meat of the poor' and the current grain legume consumption among rural children does contribute to their protein intakes, the main nutritional benefit of increased legume consumption is improvement of micronutrient adequacy. Besides food-based recommendations, other interventions are needed such as food-based approaches and/or fortification or supplementation strategies to improve micronutrient adequacy of infants and young children in rural Ghana.

Waiting for measurements in Bawku West district

Table 5 Final sets of selected food-based recommendations including additional extra recommendations for grain legumes for young children per age group and breastfeeding state, and the remaining problem nutrients.

Foods	**6-8BF**	**9-11BF**	**12-23 BF**	**12-23 NBF**
Breast milk	Every day	Every day	Every day	
Vegetables	3 servings	2 servings of dark green leafy vegetables	2 servings of dark green leafy vegetables	2 servings of dark green leafy vegetables
Dairy	1 serving		1 serving	
Whole grains		3 servings	1 serving	1 serving
Fruits		1 serving	1 serving	
Fish		3 servings		1 serving
Nuts and/or seeds	1 serving		3 servings	3 servings
Beans	1 serving	1 serving	1 servings	1 servings
Extra cowpea			*1 serving*	*1 serving*
Extra soybean	*1 serving*			
Problem nutrients without addition of extra legumes	calcium, niacin, iron, zinc	calcium, iron, zinc	calcium, iron	calcium, vit. A, vit. B_{12}, vit. C
Problem nutrients with addition of extra legumes	*iron, zinc*	*calcium, iron, zinc*	*calcium, iron*	*calcium, vit. A, vit. B_{12}, vit. C*

6-8 BF = breastfed children of 6-8 months, 9-11 BF = breastfed children of 9-11 months, 12-23 BF = breastfed children of 12-23 months, 12-23 NBF = non-breastfed children of 12-23 months.

Currently, we are conducting a modelling exercise using the results of the above study as constraints for an optimised diet for an average Ghanaian household throughout the year and investigating what are the 'food gaps' in specific seasons and what agricultural interventions would potentially best close these gaps. Preliminary results show that an average farm household in Ghana cannot be self-sufficient in providing all household members with a nutritious diet throughout the year. In the second half of the dry seasons the availability of vegetables and fruits is too low to cover their needs. Improvements in storage methods and/or irrigation options can close these gaps. In case irrigation possibilities are available for an average household, we found that a household need 1.43 ha of land to be self-sufficient and earn an additional farm income that is sufficient to cover food needs that cannot be produced at the farm but are needed for a nutritious diet.

Ahead, I have a lot of final writing to do as I am planning to hand my thesis at the end of October! So hopefully coming soon: a link to my thesis!

Ilse de Jager, Wageningen University & Research, The Netherlands (Click here for her 2017 update)

Exploring options to enhance biological nitrogen fixation and yield of soyabean and common bean in smallholder farming systems in Rwanda

After my last PhD updates, a paper was published in the N2Africa Special Issue of Agriculture, Ecosystems and Environment as Rurangwa, E., Vanlauwe, B., Giller, K.E., 2018. Benefits of inoculation, P fertilizer and manure on yields of common bean and soyabean also increase yield of subsequent maize. Agric. Ecosyst. Env. 261, 219-229. https://www.sciencedirect.com/science/article/pii/S0167880917303651.

Here I present grain yield (Fig. 2) of climbing bean from a paper I am currently working on. In Rwanda the cultivation of climbing bean is increasing especially in the highlands of the Northern Province. Although this area has favourable conditions for the cultivation of climbing bean, very high population density has resulted in small landholdings which are repeatedly cropped with little or no fertilizer, and smallholder farmers in the area achieve poor yields. Climbing beans provide cover during the growing season and valuable residues for livestock feed. Improved cover of climbing beans helps in suppressing weed growth as well as reducing water and soil loss from the steep slopes observed in the Eastern African highlands.

Field experiments were conducted in farmers' fields in Muko and Kinoni villages in the Northern Province of Rwanda. Fields in Muko were identified as high potential and those in Kinoni as low potential in terms of soil fertility. We evaluated the effect of mineral N, P and K fertilizers (both alone and in combination) and manure on the productivity of climbing bean in the two villages (seven fields in each). The results showed that application of fertilizer and / or manure significantly (P<0.001) increased the grain yields at both sites (Fig. 2). Kinoni site had significantly (P<0.001) smaller grain yield than Muko site. Average grain yield was 2.8 t ha^{-1} and 4.1 t ha^{-1} for Kinoni and Muko respectively. Application of fertilizer inputs led to greater yields in all fields of the study sites. From this study it is clear that the influence of management overrides and farmers in the area are advised to prioritise agronomic management if they are to benefit from their tiny lands (Fig. 1 & 2).

Figure.1. Climbing bean grown: (A) with no inputs added, and (B) with inputs added at Muko village

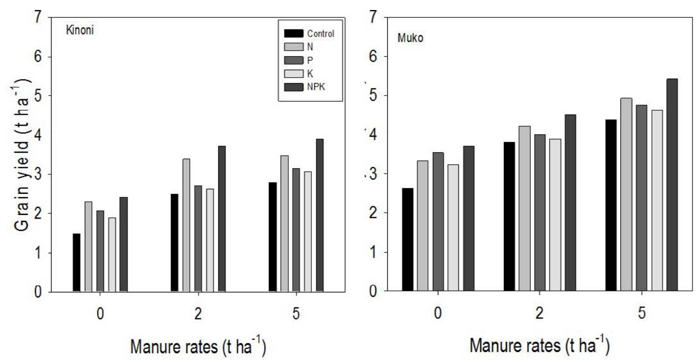


Figure 2. Climbing bean grain yields as affected by inputs at Kinoni and Muko villages; Control: no inputs added

Edouard Rurangwa, Rwanda Agricultural Board (RAB), Rwanda and Wageningen University & Research, the Netherlands (For his 2017 update click here)

Diversity of soyabean root nodule bacteria recovered from Zimbabwean soils

Zimbabwe has a long history of soyabean breeding programmes that have developed many improved soyabean varieties with various disease tolerances; and high yields, up to 5t/ha. Soyabean can depend on symbiotic nitrogen fixation (SNF) with root nodule bacteria for their entire nitrogen requirements. In comparison to use of inorganic nitrogen fertilizers, SNF is comparably inexpensive and environmentally friendly. Effective soyabean root nodule bacteria (RNB) populations in Zimbabwean soils are too erratic to be depended on for economic yields of soyabean. Inoculating soyabean seed with elite root nodule bacteria at planting, is a cheap insurance for effective SNF. For more than thirty years, Zimbabwean inoculants for soyabean, at the Soil Productivity Research Laboratory, where Mazvita works and currently leads inoculant production, carry the elite strain MAR 1491. However, the strain has been shown to exhibit limited saprophytic competence.

Indigenous rhizobia are expected to show greater resilience to the agro-climatic conditions of Zimbabwe, since it is their origin. In the present study, we prospected for indigenous root nodule bacteria from smallholder farms and soyabean breeding facilities, seeking superior adaptation to agro-climatic conditions and higher nitrogen fixation capacity, to recommend for use as new rhizobia inoculant strains.

One hundred and thirty-seven isolates were recovered and characterized for their morphology on culture medium. All isolates were slow-growing and fell in to one of two categories based on the wet or dry colonies. Partial sequences of six genes were compared for their polymorphisms using twenty isolates, and recA gene was found to be most informative. Subsequently, all 137 isolates were submitted to partial recA gene sequencing. This distinguished the isolates into four species of Bradyrhizobium, with only 13 % of isolates identifying with the species that was inoculated, *B. diazoefficiens*. Sixty percent of all isolates recovered are *B. elkanii* which was never inoculated into the soils and five percent belongs to *B. diazoefficiens* species, which has only been reported in Canada and Brazil. There was greater diversity on the smallholder farms than on the soyabean breeding facilities, despite that there were more isolates recovered from the latter. Representatives of the four species were submitted to further tests, including host-range tests and an interesting pattern of effective and ineffective nodulation or lack of nodulation was found with *Crotalaria juncea*, *Vigna radiata* and *Phaseolus vulgaris*.

All isolates were screened for nitrogen fixation, in batches, and in comparison to the elite standard strain MAR 1491, under glasshouse conditions. Isolates were highly variable in their nitrogen fixation, between and across species. The best two isolates from each species were submitted to field testing at three sites in Zimbabwe. *B. elkanii* isolates had the highest nodulation while the highest nitrogen fixation was generated by *B. diazoefficiens* and decreased in the order *B. japonicum* > *B. elkanii* > *B. ottawaense*. Isolates NAZ 710, NAZ 629 and NAZ 626 are recommended for use as rhizobia inoculants for soyabean in Zimbabwe. Mazvita has spent the last year putting together a thesis for examination.

Mazvita Chiduwa, pursuing a PhD with Murdoch University, Australia, supervised by Ravi Tiwari, John Howieson, Julie Ardley, Graham O'Hara and Paul Mapfumo, in the final stages of writing up her thesis. (Click here for her 2017 update)

Participatory approaches to diversification and intensification of crop production on smallholder farms in Malawi

This is the title of the PhD thesis that I will be defending on 12th September 2018. It was a challenging year combining the last stretch of the PhD with a busy job, but I am glad to report progress. Our third paper 'Exploring the yield gap of orange-fleshed sweet potato varieties on smallholder farmers' fields in Malawi' was published online in Field Crops Research in November 2017. (See link)

After this I focussed on the chapter 'Exploring fertilizer use with maize, legumes and sweet potato to intensify and diversify cropping systems in Malawi' which was submitted to Experimental Agriculture in April 2018. Together with a private sector partner Farmers World Ltd, we explored yield responses to inputs in 50 maize, 28 soyabean, 24 groundnut and 26 sweet potato on-farm trials and conducted economic analysis and focus group discussions. Due to proper crop management and the use of good varieties in a season with above-average rainfall, excellent mean trial yields of 5.0 t ha^{-1} for maize, 3.4 t ha^{-1} for soyabean, 2.5 t ha^{-1} for groundnuts and 13.2 t ha^{-1} for sweet potato were achieved (Figure 1). Responses to combinations of inorganic fertilizer and lime were highly variable, although yields of all crops were enhanced. Although maize production and response to fertilizer were not as profitable as the other crops, fertilizer application to maize gave the best returns of food per amount of money invested. Yield responses and value cost ratios showed that investments in fertilizer and lime on soyabean was more worthwhile than on groundnut, although the relative differences were somewhat hidden by high groundnut prices.


Figure 1. Exceptionally good yields were achieved on the demo-sites

While there is potential to derive better financial returns from diversification and intensification with legumes and sweet potato, farmers prioritize maize in terms of land area and resource allocation. Policies to enhance crop diversification and intensification should address the main constraints of lack of awareness of the agronomic and financial benefits of nutrient application to legumes and sweet potato, unstable markets, access to credit and access to improved seed.

Although my research was not directly funded by N2Africa, I linked up with Linus Franke and Ken Giller who supervised my analysis and writing – and my results contributed to knowledge generation used within the project.

I am currently working as country manager at the International Potato Center (CIP) in Malawi. I have managed the 'Feed the Future Malawi Improved Seed Systems and Technologies' project that aimed to scale out orange-fleshed sweet potato technologies to thousands of households in Central and Southern Malawi. I am currently also leading the contributions of seven International Research for Development Centres (CGIAR) to a Farmer Field School focused innovation systems project to enhance productivity of 400,000 farm households in partnership with GIZ, FAO, Government of Malawi and a consortium of NGOs.

Daniel van Vugt, International Potato Center (CIP), Malawi (For his previous update see here).

Former PhD students

Dr **Amaral M. Chibeba**, from Mozambique, was award a PhD Scholarship by Wageningen University, through the N2Africa Project, and studied at Londrina State University in Brazil (2012 – 2016). He addressed the problem of inoculation barrier imposed by indigenous rhizobia to inoculant rhizobial strains resulting in low inoculation responses and low yields in soyabean. Amaral Chibeba hypothesized that indigenous rhizobia with potential for use in inoculants for soyabean do exist in Mozambican soils and the if elite indigenous rhizobia are inoculated back in their original soils will perform better than the exogenous strains. A total of 87 indigenous rhizobial strains collected in Mozambique was screened in the greenhouse in Brazil along reference strains used in inoculants for soyabean in Brazil (SEMIA 587, SEMIA 5019, SEMIA 5079 and SEMIA 5080) and in many countries including Africa (USDA 110). Five indigenous strains from Mozambique had similar or better symbiotic effectiveness than the reference strains suggesting that the inoculation with indigenous rhizobia adapted to local conditions represents a possible strategy for increasing soyabean yields in Mozambique.
Dr. Chibeba is currently working for IITA as Postdoctoral Fellow and the main objective of his position is to evaluate the performance of the five promising indigenous strains identified in his PhD studies under field conditions.

Dr **George Mwenda** wrote: “One year after graduating, I conduct laboratory teaching at Murdoch University, Perth, Australia in units for students enrolled in Crop and Pasture Science, Veterinary Science and other Biological Science Degree programs. In this role, I teach students theoretical coursework knowledge, demonstrate research and experimental skills, and supervise research projects. I am also actively involved in N_2 fixation research at the Centre for Rhizobium Studies, Murdoch University, where as a Research Associate I participate in various BNF research activities. For further details on ongoing research at the CRS, use the following link: www.crs.murdoch.edu.au/.”

Dr **Esther Ronner** wrote: After defending my PhD in April 2018, I continued working in N2Africa as a postdoc. I am involved in the coordination of N2Africa’s impact assessment. My practical experience in data collection (measurements in the field, surveys) are of great value to understand what would and would not be possible to measure in a household survey. The qualitative data collection methods that I applied in my PhD also helped to contribute alternative methods for impact assessment. A major aim of my PhD was to understand the role of legumes in the wider farming system, and to assess which criteria farmers’ (and other stakeholders) use to evaluate benefits of and constraints for legume cultivation. The ability to look beyond yields, beyond the field level and beyond ‘the average farmer’ is something that I will not only apply in my continued work for N2Africa, but also in future jobs.

Former MSc students

Joseph Mhango, a Malawian former N2Africa sponsored MSc student, completed his MSc in Soil Science at Egerton University (Kenya) in 2015. His research was on bio-prospecting for physiological diversity of indigenous *Bradyrhizobia* species testing their nitrogen fixation efficiency in comparison with the USDA110 strain. After his MSc, he worked for 2 years as a soyabean seed production and technology dissemination officer at IITA in Malawi. On this role, he used his knowledge on nitrogen fixation for the setup of demonstrations of rhizobia inoculant efficacy as well as the preparation and delivery of related training materials. He currently works as a Research Associate under Cassava Breeding for IITA Malawi.

“My name is **Mesfin Fenta.** Currently am working in Gondar Agricultural Research Center, Amhara Agricultural Reseach Institute as Socioeconomic research assistant. My specialzation (MSc 2017) is Agricultural Economics at University of Gondar, Gondar, Ethiopia by financial support (Fellowship award) of N2Africa project, ILRI, Ethiopia. I have got good knowledge on research problem identification, data analysis, interpretation software and the subject matter. In addition, I got good experience on improved technologies distribution and approach of public private partnership.”

Jan Hüskens, Dutch MSc student who graduated in 2-015 wrote: “I am currently working for the Dutch-South African cassava processing company Dadtco Philafrica (part of Philafrica Foods). The company has a number of mobile cassava processing factories in Mozambique and Ivory Coast which supply starch flour and paste to local bakeries and breweries. The factory is mobile because of the perishability and poor infrastructure which limit transport of cassava over long distances. The main goals of the company are to provide cassava farmers with a reliable market and to substitute expensive wheat and barley imports with local produce.
In 2016, I started as a Young Expert (Young Expert Programme) and was based in Mozambique for two years. My main tasks are assisting the local supply chain and QC/QA teams. Since the company is still quite small, I have to be a jack of all trades. This makes the work very diverse and never boring. At the moment we are not doing that much on agricultural training, so I haven’t had much chance to put what I have learned during my studies into practice. During my N2Africa internship I practiced with creating surveys for mobile devices. This knowledge now comes in handy as I am leading the

change to a new data collection program for the supply chain. The experience with Life Cycle Assessments during my MSc-thesis is valuable as we are now working together with WUR to determine the environmental impact of our cassava starch products.“

Laurie van Reemst who finished her Wageningen MSc in 2016 wrote: “Currently, and since I graduated, I'm working for Wageningen Environmental Research, as an agricultural researcher on natural resource management, soil fertility and integrated farming systems. During my thesis research for N2Africa, I lived on Mt Elgon in Uganda for a couple of months, working on climbing bean adaptation by farmers. Totally unexpected, I was send back to Uganda again, and I'm currently living there still. The knowledge I gained from the field work I did, the people I met, the agronomy of legumes I had to understand during my thesis research is what I still use, almost on a daily basis. When talking with farmers I always seek to find the way they use legumes in their system, and in my Integrated Soil Fertility Management trainings I always spend sufficient time on legumes, showing them the benefits, asking them for their own experiences with legumes and explaining them how legumes can have many benefits, integrating it on different levels to their farm management, based on their farming systems and most important farm output.“

Donald Siyeni from Malawi, a beneficiary of N2Africa MSc scholarship in 2016 wrote: “The knowledge gained during and after graduation has been put into direct use. I have been implementing a more similar work to my MSc thesis research work with Agricultural Productivity Programme for Southern Africa (APPSA) for 3 years in which I have been out scaling use of Rhizobia inoculant and Fertilizer application to Soyabean. I hope to publish the results soon. Aside to that, I was also evaluating rhizobia strains for soyabean and groundnut produced and marketed by BASF which led to eventual release by the Agricultural Technology Clearing Committee (ATCC) in Malawi (in October 2017). Proudly, we have now new strains on the market from this work for soyabean and groundnuts. I wish if I had access to more strains produced by N2Africa for further testing under Malawian conditions.”

“I am **Sisay Belete** from Ambo University, Ethiopia. I was among the beneficiaries of N2Africa project graduate research fellowship during my study of MSc in Animal nutrition at Hawassa University. My research title was *“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”*. The research was conducted with close collaboration with N2Africa project partnership institutions in Ethiopia and I received full sponsorship for the research from the project.
During my MSc thesis research work, I have built immense practical knowledge and skills in the area of my specialization (Animal nutrition) as well as how to conducted research.
It was also an opportunity to get practical experience in the animal nutrition laboratory at ILRI-Addis Abeba campus, Ethiopia. Now I am working as lecturer at Ambo University, department of animal science. I am giving the courses such as *‘Forage & Pasture Crops Production & Management, Principle of Animal Nutrition; and Applied Animal Nutrition & Feed Processing* for animal science students and the course *Animal Feeds and Nutrition* for veterinary science students at Ambo University. In addition to the teaching work, I am also on the way to become engaged in some community based research and services which are conducted with my University for the local communities in the area of my specialization. Generally, I feel that the project significantly contribute in my professional qualification which in other hand benefits the country.”

Eva Thuijsman – Research assistant with N2Africa in Wageningen: “For my MSc internship and thesis with N2Africa at Wageningen University I did research in the highlands of Uganda (on adaptation trials) and Tanzania (on maize-bean intercropping) in 2015 and 2016. The diverse work – surveying, crop measurements, dealing with qualitative and quantitative data, meeting farmers, working outdoors and indoors – and the international team appealed to me a lot and I was very grateful for the opportunity to stay on as a research assistant with N2Africa after graduating in April 2017. I now mainly use the experience gained during my field work to analyse and interpret household data. Working with N2Africa I continue to learn a lot about the challenges farmers face and about the scope and tailoring of project interventions and sustainable intensification.”

Verena Mitschke: “After completing my MSc International Development Studies at Wageningen University in March 2017, I moved to Kampala, Uganda to intern for the German Society for International Cooperation (GIZ) from April to September 2017. I worked for the energy access partnership *Energising Development* (EnDev), which is active in 25 countries in Africa, Asia and Latin America and promotes sustainable access to modern energy services for the poor. Afterwards, I volunteered for a German refugee centre until I moved to Brussels, Belgium in June 2018 to work for the European Group of the International Federation of Organic Agriculture Movements (IFOAM EU) that aims for the adoption of ecologically, socially and economically sound agricultural systems based on organic principles. Thanks to my work with and for N2Africa, I was able to improve my organisation skills, my ability to work in foreign countries and communicate with people from different cultural backgrounds, and gained vast knowledge on the agricultural value chain, the agricultural production cycle and nitrogen fixation."

"I am **Bharathwaj Sridhar**, an N2Africa intern from Wageningen University 2014-2015. I presented my internship report on Adoption of climbing beans among small holder farmers in Kashambya subcounty, south western Uganda.
I am currently the Business Developer of FSMC (India), a subsidy of Waste (The Netherlands). We work with co-composting activities across India. The knowledge of market research, understanding rural communities, which I use very much nowadays today, apart from designing scientific tools for rural ethnocentric approach were my biggest learnings from N2Africa. To present my experience in a single sentence, it carved my career towards working for development of rural communities."

Martin Koinange, a Kenyan MSc student who finalized his studies on "*Influence of biochar amendment on the effectiveness of elite Kenyan rhizobia nodulating common bean (Phaseolus vulgaris L.)*" in 2015, is currently working with MEA Limited as the Biofix Manager. Biofix is a Rhizobia-based legume inoculant, manufactured by MEA Limited under the licensing of University of Nairobi. His duties are 1) Maintain existing customer accounts and continually recruit new distributors and acquire new customers, 2) Manage the Biofix® production and oversee quality control, 3) Design, set-up and organize product demonstration sites and farmer trainings, 4) Provide extension services to clients, 5) Manage all customer service, relationships and queries. Also handle feedback relating to the product, 6) Design and implement marketing strategies to increase sales/market share, 7) Maintain a healthy relationship with the product licensor, 8) Ensure that the existing product registration and licenses are up to date, 9) Liaise with the Ministry of Agriculture, Livestock and Fisheries, Universities, agricultural based institutions on matters relating to quality, crop production and marketing.

Elise Bressers accomplished her MSc thesis research within the N2Africa project in 2014: "Together with my research partner Jori Langwerden I went to the Usambara Mountains in Tanzania where we conducted several fertilizer field trials with common bean. We focussed on the relation between Rhizobia inocultation and NPK fertilization. The location was somehow special in the sense that my supervisor Ken Giller already did some fieldwork at the Usambara's in the early nineties. After finishing my MSc I started working at a company in the Netherlands focussed on the production of fertilizers (mainly trace elements) and compost. As a R&D employee my activities are mainly focussed on plant experiments, in a controlled greenhouse or in large scale field trials. Putting theory into practice and supporting famers with quality product challenges me everyday. I really enjoy working with plant experiments and the experience and knowledge I gained within the N2Africa helps me a lot in this. I still like to think back on the good times in Tanzania and the great people I met."

Jori Langwerden wrote: "Together with Elise Bressers I did my master thesis as part of the N2Africa programme in the Usambara Mountains. My research goal was to determine the soil constraints for the production of common bean. Since graduation I have been working at SMK, a Dutch NGO that develops and manages sustainable certification standards for plant products. In this position I develop and implement criteria for good agricultural practices. The knowledge I gained during my MSc is very useful for this, especially knowledge about farming systems and the limiting environmental factors for plant growth. During our fieldwork for N2Africa we worked very closely with farmers, which provided me insight in their perspective and the challenges farmers face, which I believe will be useful for my entire career. I valued to be part of N2Africa because it made you part of a large network that shared knowledge, giving an useful impression of the different


Curious children in southwestern Uganda (Photo credits Eva Thuijsman)


Maize/bean intercropping in the northern Tanzanian highlands

activities that go behind a large research programme. My research with N2Africa was a very useful and enjoyable experience, and I'm still very thankfull for it.“

Lisa Piper, who did her internship in 2016-2017 wrote: “Since graduating I have been working for SoilCares Research in Wageningen on the Cropmon project. Cropmon is a project, funded by the Geodata for Agriculture and Water (G4AW) facility. It aims to develop and make available an affordable information service that provides farmers information that helps them to make improved farm management decisions during the growing season. Farmers receive SMS messages based on near real-time satellite imagery and a variety of spatial data layers such as actual weather data, soil analysis data and farm data that inform them on their crops growth. As the crop production researcher my main role on the project is to analyse and link the technical remote sensing data to farm level reality, to develop suitable crop specific and timely SMS messages to be sent to farmers. I am also leading the projects M&E activities where I utilise the skills and experiences from my N2Africa Internship.

Gifty Kumah, who did her MPhil in 2016, is now working with Ghana Education Service (GES) in Ghana as subject teacher at Volo Community Senior High in Volo Volta Region, (West Africa), teaching Agriculture (crop husbandry): “N2Africa has equipped me with technical know-how in crop production. The experience gained, had professionally build my capacity for the teaching work. The practical work with N2Africa has given me the exposure to understand the different types of crops, their soil and growth requirements in Ghana. This work experience with N2Africa has increased my expertise in teaching my students to appreciate the various crops grown under the unimodal and bimodal rainfall regimes in the country. I am therefore grateful to N2Africa for this opportunity given me through their support.

Ibrahim Muhammed Mustapha wrote: “I was an MSc scholar at the Ahmadu Bello University Zaria, Nigeria from 2015-2017. I worked on the optimization of biological nitrogen fixation and yield of groundnut in a savanna alfisol through fertilizer application and soil amendment. My participation in the project improved my knowledge in the production, use and handling of rhizobium inoculants as well as basic microbiology techniques. As a lecturer in soil microbiology at the Federal University of Agriculture, Makurdi, Nigeria, I have been able to incorporate practicals which hitherto was not done in my institution, despite the unavailability of certain equipment. I have also been able to introduce these concepts I learned into my undergraduate project students so that more information will be derived in the southern guinea savanna of Nigeria. I currently supervise seven undergraduate project students on topics ranging from improving biological nitrogen fixation using Bradyrhizobium japonicum and fertilization in legumes to assessing microbial activities after the use of herbicides. These skills being inculcated to others would not have been achievable to this extent without the support of the N2Africa project, which is duly acknowledged.“

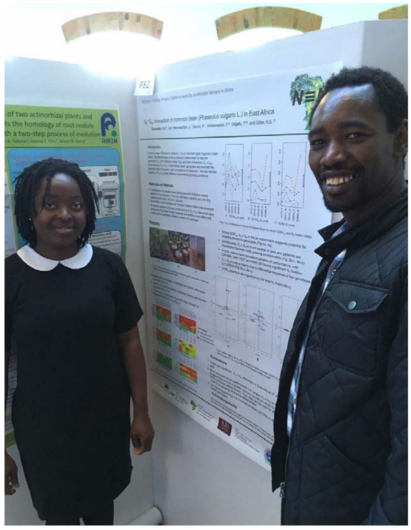
Yusuph Namkeleja who wrote his disseratioin in April 2017 wrote: “Currently am working with the Tanzania Wildlife Management Authority (TAWA) under the Ministry of Natural Resources and Tourism as a Wildlife Officer in Kilombero Valley Ramsar Site/ Kilombero Game controlled Area (KVRS/KGCA). My key responsibility is to ensure conservation of the wildlife resources as well as encouraging wise use of those resources through awareness creation, providing conservation education, research and patrols. The knowledge I gained during my MSc studies help in my daily working activities as I studied Msc in Life Sciences and Engineering specializing in Biodiversity and Ecosystem Management which collate with my job. Also it helps me to impart the wide perception of biodiversity that biodiversity conservation shall not focus only in large mammals, birds, reptiles and plants, but have to extend to the microorganism as microorganism is the overlooked unit which is very important for the survival of the whole and all ecosystems. And if microorganisms are well and deeply explored, they may, indirectly, bring a lot of income. Concerning Rhizobilogy knowledge I am not using it directly in my working environment.”

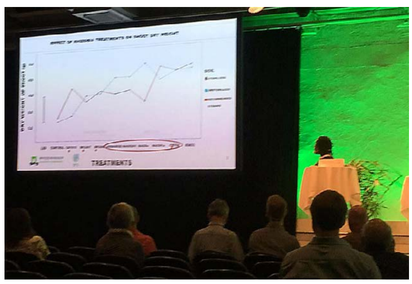
European nitrogen fixation conference

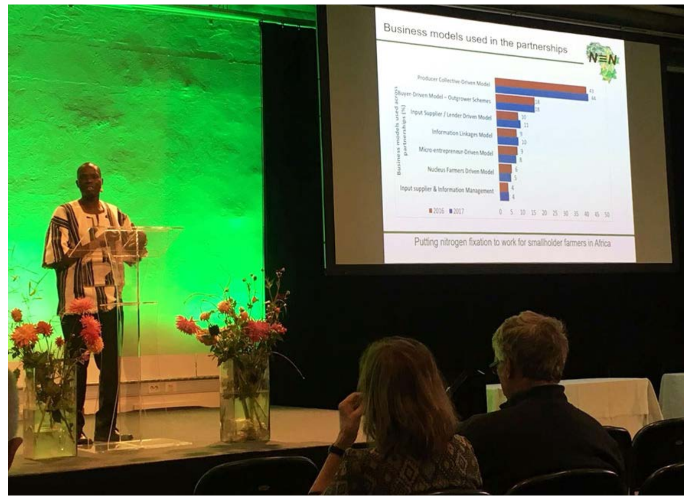
We (Comfort and Ashenafi) had the opportunity to participate in a 13th European Nitrogen Fixation Conference and a side by side Satellite Workshops from 18-21 August 2018 at München-Bryggeriet in Stockholm, Sweden. We presented our works by a poster (Ashenafi) and pitch speech (Comfort) at the Conference. It was a great opportunity for us to introduce ourselves and works to high-level profile professionals in the field of nitrogen fixation and share their experiences and expertise.

We have learnt that most of the works presented focused on understanding signalling mechanisms and evolutions of symbiosis formation and nitrogen fixation; structural organization and functionality of nitrogenase enzymes that is responsible for nitrogen fixation; transforming symbiosis formation and nitrogen fixation traits to none-legume or none-nitrogen fixing plants. Besides legume-rhizobium symbiosis, several other forms of symbiotic and non-symbiotic nitrogen fixation forms including symbiotic nitrogen fixation in aquatic ecosystems, in arctic environment,

in mosses, in free living bacteria and cyanobacteria and in symbiotic fungi were presented. We have seen that this community has accumulated a huge knowledge of basic and applied aspects of symbiotic nitrogen fixation.
We recognized that the conference failed to prevail nitrogen fixation applications beyond the sophisticated lab and greenhouse works to solve soil nitrogen limitation problems of resource poor farmers. However, Peter Ebanyat's N2Africa work presentation signalled a fantastic home take message to the audience. With this regard, our involvement in research for tackling problems related to inoculants and their quality as well as screening elite strains for inoculant redesigning would mean a lot and need to be promoted. As a project, N2Africa was well credited for putting nitrogen fixation to work in small holder farmers. The final panel discussion, chaired by Eva Kondorosi, delivered a strong home take message that EU parliament should support nitrogen fixation projects and Tom Bisseling (Panel member from Molecular biology lab of WUR) delivered a strong message for the audience to work on short term plan to make biological nitrogen fixation work in fields.


Ashenafi at his poster with Comfort


Comfort giving a 3 min speed talk



Peter Ebanyat Talking about business models presenting N2Africa at the European Nitrogen Fixation Conference in Stockholm

Ojo Comfort Tinuade and Ashenafi Hailu Gunnabo, Wageningen University & Research, The Netherlands

Reports and other output uploaded on the N2Africa website

- MSc thesis "Adoption of improved soyabean varieties: the case of Buno Bedele and East Wollega zones of Oromia Region, Ethiopia" by Galmesa Abebe;
- MSc thesis "Influence of potassium fertilization and liming on growth, grain yield, and quality of soybean (Glycine max L. (Merrill) on acidic soil in Gobu Sayo District, western Ethiopia" by Negash Teshome.

N2Africa publication

Variations in seed and post-harvest residue yields and residues quality of common bean (Phaseolus vulgaris L.) as a ruminant feedstuff. 2018. Dejene, M., Dixon, M.B., Duncan, A.J., Wolde-meskel, E., Walsh, K.B., McNeille, D.

Related newsletters

- Four FAO news items: Healthy soils are essential to achieve Zero Hunger, peace and prosperity, A violet chair to give indigenous women a seat at the table, New programme to boost soil productivity and reduce soil degradation in Africa and Knowledge-sharing and partnerships are key to eradicating poverty and hunger by 2030;
- IITA news: IITA…Enabling Youth in Agriculture;
- Soybean Innovation Lab Newsletter: July 2018;
- ICRISAT news: Major step forward in chickpea and pigeonpea research – reference genome data assembled;
- SAIRLA news: Linking farmers with providers of inputs for sustainable production.

The Podcaster is published six to eight times per year – we look forward to receiving news and contributions – particularly from partners. Please send in contributions well in time. Contact address for this newsletter is: N2Africa.office@wur.nl

Please feel free to forward this email to colleagues you believe would be interested. This email has been sent to you by N2Africa, funded by The Bill & Melinda Gates Foundation.

When you change your e-mail address and want to keep receiving the Podcaster, please send your new address to N2Africa.office@wur.nl. If friends/colleagues like to receive future Podcasters let N2Africa.office@wur.nl know as well.

If you want to unsubscribe please send a message to n2africa.office@wur.nl