Evaluation of the progress made towards achieving the Vision of Success in N2Africa

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N2Africa

Putting nitrogen fixation to work for smallholder farmers in Africa

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Abstract

This report evaluates the progress made during Phase 1 of the N2Africa project in reaching the Vision of Success. This report also covers Milestone 1.6.1 (A report on the impact of N2-fixation technologies on farmers' livelihoods is produced) and Milestone 2.6.1 (Household benefits from specific BNF interventions quantified for the four major grain legumes in the impact zones). The Vision of Success in N2Africa, Phase 1, project was formulated as follows: *'To raise average grain legumes yields by 954 kg/ha in four legumes (groundnut, cowpea, soyabean, and common bean), increase average biological nitrogen fixation (BNF) by 46 kg/ha, and increase average household income by $465, directly benefiting 225,000 households (1,800,000 individuals) in eight countries in sub-Saharan Africa.'* Based on data collected in the N2Africa project and from literature and a set of assumptions explained in the Methodology and discussed in the Discussion section of this report, a quantitative evaluation of the progress towards achieving the Vision of Success during the N2Africa project is made.

A summary of the findings is given in Table 1. The analyses suggest that the N2Africa project has been successful in targeting large numbers of households in the N2Africa countries through the distribution of N2Africa packages containing legume technologies and training. The project has not yet achieved the target figures for increases in legume grain yield and BNF per ha. This is related to the partial use of N2Africa technologies by farmers. With the adoption of the full N2Africa package, the expected increases in yield and BNF will be considerably larger, but especially for yield still insufficient to reach the target in the Vision of Success. Given the large gap between current and attainable yields, as indicated by the difference in yield between that achieved by the best performing farmers and the average yield in a region, it may be well possible to further increase yields substantially if yield limiting factors can be tackled effectively. Household benefit from an intensification and expansion of legume production was relatively close to the target in the Vision of Success. Rotational benefits of legumes on subsequent non-legume crops and the expansion of the area cultivated with legumes were major drivers behind this increase in household benefits. It is expected that the full impact from the N2Africa project will be achieved only 5-10 years after the project has ended.

Table 1: Table 1. Summary of the progress made towards achieving the Vision of Success in N2Africa.

Target in Vision of Success	Achieved
Directly benefit 225,000 households	253,299 households
Raise average grain yields by 954 kg/ha	
Bean	139 kg grain/ha
Cowpea	117 kg grain/ha
Groundnut	78 kg grain/ha
soyabean	272 kg grain/ha
Increase biological nitrogen fixation by 46 kg/ha	
Bean	22 kg N/ha
Cowpea	9 kg N/ha
Groundnut	7 kg N/ha
soyabean	41 kg N/ha
Increase average household income by $465	$355 per household

1 Introduction

The Vision of Success in N2Africa, Phase 1, project has been formulated as follows: *'To raise average grain legumes yields by 954 kg/ha in four legumes (groundnut, cowpea, soyabean, and common bean), increase average biological nitrogen fixation (BNF) by 46 kg/ha, and increase average household income by $465, directly benefiting 225,000 households (1,800,000 individuals) in eight countries in sub-Saharan Africa.'* This document aims to evaluate the extent to which the N2Africa project has currently (October 2013) achieved the Vision of Success. An earlier assessment of the progress towards achieving the Vision of Success when the project was at the halfway stage was conducted by Woomer et al. (2012).

The four main statements in the Vision of Success are evaluated in this report:

1. To directly benefit 225,000 households.
2. To raise average grain yields by 954 kg/ha.
3. To increase biological nitrogen fixation by 46 kg/ha
4. To increase average household income by $465.

2 Methodology

2.1 To directly benefit 225,000 households

Here we consider the number of farmers that received tangible inputs from N2Africa, usually in the form of a legume package containing legume seed, legume fertiliser and inoculant in the case of soyabean and sometimes bean, as well as training on legume production methods and sometimes legume processing. Data on the number of farmers who received an N2Africa package was provided by the dissemination partners and collated by the N2Africa country coordinators.

2.2 To raise average grain yields by 954 kg/ha.

An estimation of the response of grain legumes to the use of inputs promoted by N2Africa was obtained from the demonstration and dissemination trials carried out by N2Africa's dissemination partners. A sample of these trials (around 300 trials per country per season) was monitored intensively by N2Africa staff, providing data on average yield increases in response to N2Africa technologies and the variability therein on a wide range of farmers' fields.

The yield data extracted from the dissemination and demonstration trials are given in Table 2. In a few instances, no yield data from dissemination and demonstration trials were available for a specific crop. In those cases, yield increases achieved in a neighbouring country were used, as indicated in the footnotes of Table 2. Climbing beans have been promoted in Kenya but were neglected in the current assessment. The role of climbing bean in the dissemination program of Kenya was small and the results from the early impact survey suggested that the impact of these activities did not lead to an increased cultivation of climbing bean in the farmers' fields (in area or percentage of farmers growing the crop).

Not all farmers currently use all components of the legume packages in their own fields. The percentage of households using specific inputs in legumes in their own field has been estimated from the N2Africa early impact survey (Table 3). To obtain an average grain yield increase, a weighted average was taken of yield improvements achieved in treatments receiving legume inputs over the control yield. Weighting was done according to the percentage of farmers using specific inputs in their own field.

Table 2: Grain yields (kg/ha) in control plots without use of inputs and responses to inputs of inoculant and P fertiliser alone or in combination observed in N2Africa dissemination and demonstration trials.

	No-use of inputs	+ inoculant only	+ P fertiliser	+ P fertiliser and inoculant
DRC				
Soyabean	1,100	1,510	1,200	1,880
Bean [1]	1,340		1,970	
Kenya				
Soyabean	570	790	930	1,180
Rwanda				
Soyabean [2]	1,100	1,510	1,200	1,880
Bean	1,340		1,970	
Ghana				
Soyabean	1,160	1,340	1,340	1,470
Cowpea	870		1100	
Groundnut [1]	650		780	
Nigeria				
Soyabean	750	1,170	1,150	1,420
Cowpea	650		2,010	
Groundnut	890		1,330	

Malawi				
Soyabean [3]	840	1,170	1,200	1,640
Cowpea	1,093		1,324	
Groundnut	500		670	
Bean	1,180		1,355	
Mozambique				
Soyabean	840	1,170	1,200	1,640
Groundnut [4]	500		670	
Zimbabwe				
Soyabean	1,436	1,956	1,976	2,293
Cowpea	1,212		1,947	
Groundnut	896		1,209	
Bean	1,570	1,853	1,663	2,106

[1] Data from Rwanda
[2] Data from DRC
[3] Data from Mozambique
[4] Data from Malawi

Table 3: The percentage of farmers using specific legume inputs in their own fields, based on data from the N2Africa impact survey.

	No-use of inputs	+ inoculant only	+ P fertiliser	+ P and inoculant
DRC				
Soyabean	34	27	23	16
Bean	57	8	27	8
Kenya				
Soyabean	14	9	16	61
Rwanda				
Soyabean	55	10	18	17
Bean	72		28	
Ghana				
Soyabean	69	6	19	6
Cowpea	90		10	
Groundnut	85		15	
Nigeria				
Soyabean	6	11	57	26
Cowpea	18		82	
Groundnut	24		76	
Malawi				
Soyabean	50	10	15	25
Cowpea	77		23	
Groundnut	91		9	
Bean	67	4	27	2
Mozambique				
Soyabean	34	27	23	16
Groundnut	93		7	
Zimbabwe				
Soyabean	69	16	11	4
Cowpea	83		17	
Groundnut	97		3	
Bean	60	2	36	2

2.3 To increase biological nitrogen fixation (BNF) by 46 kg/ha.

Increases in grain yields assessed above form the basis for calculating increases in BNF. Stover yield (Yst) can be calculated from the grain yield and an assumed dry matter harvest index (HI), which represents the fraction of total aboveground dry matter in the grains:

$$Yst = \frac{Ygr}{HI} - Ygr$$

Subsequently, BNF can be calculated based on grain yield (Ygr) and stover yield (Yst), the N concentration in the grain (Ngr) and in the stover (Nst) and an assumed % of nitrogen in the aboveground parts derived from N fixation (%NDFA):

$$BNF = (Ygr \cdot Ngr + Yst \cdot Nst) \cdot \%NDFA$$

In our calculations, we assumed a dry matter harvest index of 0.35 for all legumes. Table 3 gives an overview of the N concentration of stover and grain, as well as the %NDFA for different grain legumes used in our calculations. Extensive information on factors influencing BNF and BNF measurements, and on the estimates of the values given in Table 4 are provided in the N2Africa report by Ronner & Franke (2012).

Table 4: N concentrations in grain and stover and percentage nitrogen derived from air (%NDFA) used in the calculations of BNF.

	N concentration grain (%)	N concentration stover (%)	%NDFA
Common bean	4.3	4.0	40[1] / 50[2]
Cowpea	3.5	3.1	70
Groundnut	3.9	2.2	70
Soyabean	6.0	2.5	50[1] / 70[2]

[1] Without inoculation
[2] With inoculation

2.4 To increase average household income by $465

To assess changes in household income due to increased legume cultivation, we first calculated legume yields at farm level in the old situation and in the new situation. The project had impact on: i. grain yield per ha, ii. the fraction of households cultivating specific legumes and iii. the area of a specific legume cultivated by a household. Changes in grain yield per ha have been assessed above (Table 2). Changes in the fraction of households cultivating a specific legume crop has been estimated by comparing the fraction observed in the N2Africa baseline survey, with those observed in the N2Africa impact survey (Table 5). By multiplying the average area of a legume crop (of those households growing the crop) with the fraction of households growing the crop, the average area of the crop among all households (including those not growing the crop) is obtained (Table 6).

The value of a legume crop at household level is subsequently determined by multiplying the average area of the crop among all households with the yield and the price of legume grain (Table 7). While crop areas and yields have been affected by the project, legume price was assumed to be the same in the 'old' and the 'new' situation and any value addition to the produce by farmers is neglected, because of a lack of reliable data on fluctuation in prices.

The incorporation of legumes into cereal-dominated systems in sub-Saharan Africa usually leads to substantial residual benefits for maize. A survey of literature showed indeed that impacts of legumes on maize yield are large, relative to a maize monoculture (Table 8). Based on results from the literature survey, we assumed the following (conservative) yield increases of cereals grown in rotation with legumes, relative to a monoculture of cereals:
Common bean: +20%
Cowpea: +20%
Groundnut: +50%
Soyabean: +50%

Table 5: Percentage of households cultivating legume crops in the baseline (old use) and the impact survey (new use).

	Old bean use	New bean use	Old cowpea use	New cowpea use	Old groundnut use	New groundnut use	Old soyabean use	New soyabean use
DRC	63	98					13	42
Kenya							6	92
Rwanda	95	95					20	25
Ghana			33	64	40	63	21	86
Nigeria			74	70	50	53	40	65
Malawi	24	44	17	27	84	94	25	72
Mozambique					24	36	22	44
Zimbabwe	18	36	33	33	78	80	14	50

Table 6: Average area of legumes across households (including households that do not grow the crop) (ha / farm).

	Old bean area	New bean area	Old cowpea area	New cowpea area	Old groundnut area	New groundnut area	Old soyabean area	New soyabean area
DRC	0.16	0.40					0.01	0.09
Kenya							0.01	0.20
Rwanda	0.19	0.19					0.02	0.03
Ghana			0.31	0.31	0.18	0.41	0.12	0.60
Nigeria			0.77	0.92	0.45	0.57	0.44	0.80
Malawi	0.07	0.12	0.04	0.07	0.27	0.31	0.06	0.17
Mozambique					0.10	0.33	0.14	1.20
Zimbabwe	0.06	0.10	0.06	0.08	0.25	0.31	0.05	0.06

Table 7: Local prices of legume grain and the main inputs (excl. labour) for legume cultivation (prices recorded in May/June 2013) (US$/kg).

	Common bean	Cowpea	Groundnut	Soyabean	Maize	P-based fertiliser [1]	Inoculum (US$/ha)
DRC	0.60			0.80	0.40	1.50 (TSP)	9.20
Kenya	0.56			0.61	0.34	0.97 (Sympal)	9.20
Rwanda	0.47			0.62	0.23	0.93 (DAP)	9.20
Ghana		1.20	1.10	0.89	0.22	0.90 (TSP)	5.00
Nigeria		1.20	1.13	0.60	0.59	0.56 (SSP)	5.00
Malawi	0.79		0.74	0.47	0.27		5.00
Mozambique			1.01	0.54	0.21	0.64 (SSP)	5.00
Zimbabwe	1.30	0.80	1.00	0.55	0.33	0.38 (SSP)	5.00

[1] Non-subsidised retail prices

To assess the additional maize yield obtained due to a larger area under legume cultivation, we calculated the increase in area of maize rotated with legumes (Table 5). Subsequently, we calculated the increase in maize production (using average national maize yields in 2007-2011 as a control yield, source: FAO) on this additional land under rotation. The additional maize production is subsequently multiplied with the local maize price to obtain the additional value from increased maize production.

Improved legume productivity requires investments in P fertiliser and inoculum. The costs of the additional inputs is calculated based on the price of the inputs multiplied by the recommended application rate, the area of the legume per household (Table 6), and the fraction of farmers using these inputs (Table 3). The expansion of the legume area may lead to foregone benefits from crops that could have been grown instead. We assumed that an expansion of the legume area came at the expense of the area grown with maize. Foregone benefits from maize cultivation equalled the value of the maize grain with the costs of mineral fertiliser applied to maize subtracted. Mineral fertiliser costs in maize were assumed to equal 100$/ha in all countries, except for DRC and Mozambique where farmers generally use no fertiliser at all in maize. Net benefits from enhanced legume cultivation are calculated by adding the additional value of legume and maize grown in rotation with legumes and subtracting the additional costs of inputs in legumes and the foregone benefits from maize cultivation due to an expansion of the area with legumes. The net benefits of different legume crops are added to obtain net benefits at household level. Net benefits are multiplied by the number of growing seasons in a year (two in East Africa and one in West and Southern Africa) to obtain net benefits per annum.

Table 8: Average relative increase in grain yield of maize grown in rotation with different grain legumes, compared with monoculture maize, in West Africa, southern Africa, and East Africa.

Source	Region	Country	Maize yield in control (t grain / ha)	Long-duration soyabean	Short-duration soyabean / cowpea	Groundnut	Common bean
Franke et al., 2008	W Africa	Nigeria	2.03	+93%	+55%		
Franke et al., 2010	W Africa	Nigeria	1.71			+50%	
Yusuf et al., 2009	W Africa	Nigeria	0.90	+68%	+49%		
Oikeh et al., 1998	W Africa	Nigeria	4.20	+24%			
Horst and Hardter, 1994	W Africa	Ghana	2.30		+25%		
Dakora et al., 1987	W Africa	Ghana	1.40		+31%	+54%	
Sauerborn et al., 2000	W Africa	Ghana	0.65	+191%	+151%	+207%	
Carsky et al., 2001	W Africa	Nigeria	0.29		+138%		
Kasasa et al., 1999	S Africa	Zimbabwe	1.81	+121%			
Ncube et al., 2007 *	S Africa	Zimbabwe	0.63		+117%	+108%	
Svubure et al., 2010	S Africa	Zimbabwe	0.77	+411%			+193%
Svubure et al., 2010	S Africa	Zimbabwe	0.84			+315%	
MacColl, 1989	S Africa	Malawi	2.90	+16%		+24%	
Kihara et al., 2010	EC Africa	Kenya	3.50	+31%			
Anyanzwa et al., 2010	EC Africa	Kenya	1.01	+13%			
Ojiem et al., 2013	EC Africa	Kenya	2.04	+49%		+71%	+7%

* Sorghum was used as a test crop instead of maize.

3 Results

3.1 To directly benefit 225,000 households

In total an estimated 256,410 farmers have benefitted directly from N2Africa technologies (Table 9). The N2Africa project thus exceeded the target number in the Vision of Success. 29% of these beneficiaries were based in East of Central Africa, 31% in West Africa and 40% in southern Africa.

Table 9: Number of farmers directly benefitting from N2Africa technologies for different countries.

	DRC	*Kenya*	*Rwanda*	*Ghana*
Year 1		10,515	1889	1,500
Year 2	7,710	15,177	2,124	10,320
Year 3	11,490	11,772	16,048	23,190
Total	**19,200**	**37,464**	**20,061**	**35,010**
	Nigeria	*Malawi*	*Mozambique*	*Zimbabwe*
Year 1	2,112	3,410	13,887	2,215
Year 2	11,868	10,919	14,803	6,210
Year 3	22,627	17,000	20,161	16,100
Total	**36,607**	**31,329**	**48,851**	**24,525**
Grant Total	**253,299**			

3.2 To raise average grain yields by 954 kg/ha

Yield increases were less than the target figure in the Vision of Success (Table 10). As not all farmers in the impact survey used the inputs promoted by N2Africa, yield increases are less than what could be achieved with use of the full package of inputs, but even with full adoption of the N2Africa package, average yield increases do not reach the target (Table 10). Any effects of the adoption of improved varieties or crop management outside input use have not been incorporated in these calculations. While data on the impact of different varieties on yield is available from dissemination trials from most regions, current use of improved varieties as indicated by the early impact assessment survey has not been sufficiently analysed yet. This is a priority for future analyses.

Table 10: Yield increase per crop per country as a result of the use of inputs in farmers' fields (kg grain per ha).

	Calculated yield increase achieved by the project				Expected average yield increase with full adoption of the N2Africa package			
	Bean	Cowpea	Groundnut	Soyabean	Bean	Cowpea	Groundnut	Soyabean
DRC	271			259	630			780
Kenya				450				610
Rwanda	176			192	630			780
Ghana		23	20	64		230	130	310
Nigeria		267	334	448		325	440	670
Malawi	58	53	15	287	175	231	170	800
Mozambique			14	300			170	800
Zimbabwe	50	125	9	177	536	735	313	857
Average	**139**	**117**	**95**	**272**	**493**	**380**	**211**	**687**

3.3 To increase biological nitrogen fixation by 46 kg N/ha

Increases in BNF were higher for soyabean and bean than for groundnut and cowpea, because inoculation of bean and soyabean increases the percentage of N derived from air in these crops (Table 11). Increases in BNF of cowpea and groundnut solely came from increases in productivity in the current calculations. Gains in BNF in groundnut and cowpea were limited due to minimal increases in yield and BNF in these crops in Ghana, Mozambique and Malawi. This is related to the low uptake of P-based fertiliser in these crops in these countries according to the use survey, and consequently yield increases in these crops (per ha) have been minimal. With full adoption of the N2Africa package, the expected increase in BNF would be considerably higher, but only in soyabean it would exceed the target figure of 46 kg N/ha (Table 11).

Table 11: Increase in BNF per crop per country as a result of the use of improved technologies in farmers' fields.

	Calculated BNF increase achieved by the project (kg N/ha)				Expected BNF increase with full adoption of the N2Africa package (kg N/ha)			
	Bean	Cowpea	Groundnut	Soyabean	Bean	Cowpea	Groundnut	Soyabean
DRC	29			43	48			82
Kenya				51				58
Rwanda	37			74	48			82
Ghana		2	1	29		24	33	66
Nigeria		20	25	49		17	10	48
Malawi	16	4	1	39	22	17	13	77
Mozambique			1	40			13	77
Zimbabwe	36	37	16	79	22	55	23	94
Average	**22**	**9**	**7**	**41**	**35**	**28**	**18**	**73**

3.4 To increase average household income by $465

The estimated impact of the project on household benefits was slightly below the target figure of $465 per household (Table 12). Large difference in net benefits between countries were observed. Farm size had a major impact on benefits at household level. In countries with relatively large landholding, farmers can grow legumes on a larger area and therefore achieve considerably greater benefits at household level. Having two growing season instead of one, doubled the accumulated net benefits per crop. In Kenya and Rwanda having two growing season per annum, annual net benefits were nevertheless small compared to other countries, because of very small landholdings in these areas.

Table 12: Increase in household net benefits in US$ for each legume crop and all crops accumulated per annum due to the use of N2Africa technologies.

	Bean	Cowpea	Groundnut	Soyabean	**Total net benefits per household per annum [1]**
DRC	180			69	**497**
Kenya				60	**120**
Rwanda	10			10	**41**
Ghana		22	167	476	**665**
Nigeria		162	245	10	**417**
Malawi	54	8	9	30	**101**
Mozambique			90	478	**568**
Zimbabwe	70	20	53	16	**153**
Weighed average					**355**

[1] Two seasons in East and Central Africa, one season in West and Southern Africa.

4 Discussion

The assessment of the progress made towards the Vision of Success is based on a number of assumptions that are discussed in further detail below. The number of households benefitting from N2Africa technologies is based on the number of new farmers who received inputs for legume technologies and training on legume cultivation during the project. The number of households claimed to be directly benefitting from N2Africa technologies was often higher than the number of households listed on the input distribution form, intended to capture the basic details of all households who received a package from N2Africa. Because of incomplete filling in of the input distribution form, the number of households claimed to be directly benefitting from N2Africa technologies could thus not be verified through the input distribution form in the majority of countries. Furthermore, in various countries, some households received an N2Africa package more than once. Although the number of households benefitting from N2Africa technologies was supposed to be based on the number of new households targeted with an N2Africa package, this may not always have been the case.

We only assessed the number of households directly benefitting from the project. Any households indirectly benefitting from the project, e.g. those who received improved seed from N2Africa farmers or benefitted from N2Africa training without receiving legume inputs, were excluded in this assessment. The N2Africa project has not collected data systematically on indirect household benefits of the project. However, given the speed at which popular new legume varieties and knowledge on legume cultivation can spread, the number of farmers indirectly benefitting from N2Africa technologies is likely to be substantial in cases where technologies promoted by N2Africa provided clear benefits to farmers.

The assessment of the impact of N2Africa technologies on legume yields was based on responses of legumes to the application of inputs in N2Africa's dissemination and demonstration trials and the current use of N2Africa technologies assessed in the early impact assessment. The yields achieved in these trials are expected to be fairly representative for farmers' conditions, given that the trials were conducted on-farm and implemented by farmers. For our assessment, we took an average yield and yield response observed in the dissemination trials monitored in a country (often over more than one season). This masks the fact that a wide variability in yields is recorded within areas, which is typical for multi-locational on-farm trials. This large variability is observed in all areas from where data have been retrieved. Only in cases where average yield in a given area and season was exceptionally low, for instance due to drought, this variability was reduced. This variability in responses also greatly affected the profitability of the promoted technologies for an individual farmer.

The average yield in the 25% highest yielding plots in the dissemination and demonstration trials gives an indication of the attainable yield in a region (Table 13). These attainable yields were generally much higher than the average yields with current use of N2Africa technologies or the average yield with full use of N2Africa technologies (Figure 1). Clearly, closing the yield gap between current average and attainable yield requires more than the use of N2Africa technologies alone. Enhanced understanding why certain farmers achieve only poor responses to N2Africa technologies is major research goal in the N2Africa project. If the causes for low yields can be effectively tackled, it may be possible to achieve or even exceed the impact on yield stated in the Vision of Success.

Table 13: Average yields achieved in the 25% highest yielding plots in dissemination and demonstration trials in N2Africa.

	Bean	Cowpea	Groundnut	Soyabean
DRC				2,469
Kenya				2,172
Rwanda	3,611			
Ghana		1,742	1,363	2,270
Nigeria		2,089	2,630	2,997
Malawi	1,471		1,296	2,375
Mozambique				1,449
Zimbabwe	3,613	2,487	2,487	4,258

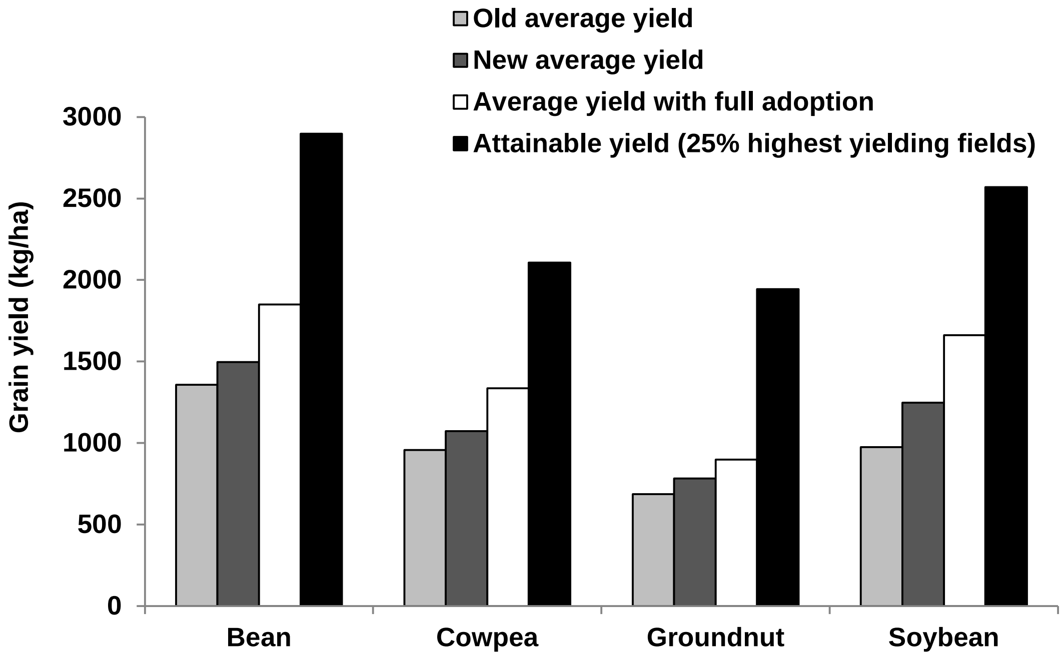

Figure 1: Average yield in the control ('old' yield), average yield with the current use of N2Africa technologies ('new' yield), average yield with complete use of N2Africa technologies, and the attainable yield as indicated by the 25% highest yielding fields.

In the assessment of the impact of N2Africa technologies on legume yields, any yield enhancing effect from the use of improved varieties was neglected, because the data on current use of promoted legume varieties has not been analysed sufficiently yet. Assessing the varietal impact on yield is associate with some additional challenges. In some cases, there is no 'local' variety as a comparison, for instance in countries where soyabean is largely a new crop. In other cases, varieties promoted by N2Africa have been part of the cropping systems for a long time already. For instance, the popular soyabean variety TGx 1448-2E has been promoted in northern Nigeria for the last 15 years by many partners, and the use of this varieties can thus not be attributed to the N2Africa project. It was thus not considered feasible to reliably estimate a variety effect in the yield assessment. Yet, there is ample evidence that the use of improved varieties did improved legume yields in various regions. **Error! Reference source not found.** gives an overview of the performance of different varieties in the dissemination and demonstration trials. Also training on legume production techniques other than the use of inputs may have increased legume productivity, but this has not been captured through the standard set of M&E tools.

As BNF is closely related to legume yield, all above-mentioned assumptions affecting yield will also affect BNF. Moreover, in the assessment of the impact of the N2Africa technologies on BNF, any below-ground contributions of legumes to the nitrogen budgets have been neglected. Below-ground plant-derived N of soyabean (TGx 1448-2E in Nigeria) has been found to constitute 16-23% of the total plant N (Laberge et al., 2009). Including below-ground contributions in this case increased total soyabean BNF by 19-30%. Probably similar figures would apply to the other legumes. Thus, including below-ground contributions of legumes to nitrogen budgets would substantially increase the expected BNF benefits from N2Africa technologies. However, figures on the below-ground contribution of BNF to nitrogen budgets are only rough estimations, because of the technical difficulties associated with measuring below-ground BNF under field conditions.

The calculation of net benefits from enhanced legume cultivation is based on a partial budgeting exercise in which not all costs and benefits have been included. For instance, labour required to grow legumes in the 'old system' and the 'new system' have not been included. It is likely that intensification of legume production will coincide with an increase in labour demand, which will reduce net benefits

Table 14: Average yield of different legume varieties observed in dissemination and demonstration trials in N2Africa.

Ghana					
Groundnut	JL24	Chinese	Samnut 22/23		
	682	743	911		
Cowpea	Bawota	Apaagbala	Padituya	Songotura	
	1591	1520	1415	1123	
Nigeria					
Soyabean	TGx 1448-2E	TGx 1835-10E	TGx 1904-6F	TGx 1935-3F	TGx 1951-3F
	1680	1427	1527	1356	1407
Groundnut	Local	RMP 91	Samnut 22	Samnut 23	
	1279	1412	1154	1712	
Cowpea	Local	IT90K-277-2			
	917	1122			
Kenya					
Soyabean	Saga	Squire	SB19		
	977	1150	1127		
Malawi					
Soyabean	Nasoko	Makwacha			
	941	1093			
Groundnut	CG7	Nsinjiro			
	621	694			
Mozambique					
Soyabean	Safari	Santa	Serenade	Storm	
	1174	1155	1163	807	
Soyabean	TGx1485-1D	TGx1740-2F	TGx1904-6F	TGx1908-8F	
	773	788	761	799	
Bean	Kalima	Kholophete			
	788	709			
Zimbabwe					
Bean	Speckled ice	Bonus	Cardinal		
	462	716	2310		
Soyabean	Saga	Safari	Serenade	Squire	
	1260	2598	2090	1924	

retrieved from the use of N2Africa technologies. However, changes in labour demands are hard to quantify. We did include an estimation of monetary benefits that could have been retrieved from a crop (assumed to be maize) replaced by an expanding legume crop. In certain countries, e.g. in Mozambique, arable land is often not limiting and an expanding legume crop does not need to come at the expanse of another crop (provided that the labour devoted to additional legume production does not reduce the farmer’s ability to grow other crops). In the majority of N2Africa regions however, farmers have limited access to arable land, and an expansion of legume is likely to come at the expense of another crop. Furthermore, we did not include price fluctuations and the effect of any value addition to crop produce in households into account. Farm gate prices of crop produce fluctuate widely in response to local, national and international market trends. Besides, it is well possible that training, e.g. on home processing of soyabean grain, resulted in value addition. A lack of quantitative data on value addition makes it difficult to include this in the calculations. In the assessment of increased household income from N2Africa technologies, the rotational effects of legumes on a subsequent non-legume crop (in our assessment assumed to be maize) had a strong impact on the total benefits for household income. According to results from the literature review (Table 8) our estimates of the rotational effects of legumes were modest. Rotational effects may thus even be larger in reality.

Finally, the statements in N2Africa's Vision of Success can often be interpreted in more than one way. For instance, household benefits may be calculated per season or per year, the latter option doubling the calculated household benefits in East and Central Africa. Also the number of households directly benefitting from N2Africa technologies may be defined in different ways. 'Benefitting' in this case may refer to receiving an N2Africa package, or to independent use of N2Africa technologies resulting in a substantial yield benefit. A lesson learned here is that the formulation of the Vision of Success and of key outcome milestones, for instance for Phase II of the N2Africa project, should leave less room for different interpretations.

5 Literature

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List of project reports

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

35. Dissemination tools produced
36. Linking legume farmers to markets
37. The role of AGRA and other partners in the project defined and co-funding/financing options for scale-up of inoculum (banks, AGRA, industry) identified
38. Progress Towards Achieving the Vision of Success of N2Africa
39. Quantifying the impact of the N2Africa project on Biological Nitrogen Fixation
40. Training agro-dealers in accessing, managing and distributing information on inoculant use
41. Opportunities for N2Africa in Ethiopia
42. N2Africa Project Progress Report Month 30
43. Review & Planning meeting Zimbabwe
44. Howard G. Buffett Foundation – N2Africa June 2012 Interim Report
45. Number of Extension Events Organized per Season per Country
46. N2Africa narrative reports Month 30
47. Background information on agronomy, farming systems and ongoing projects on grain legumes in Uganda
48. Opportunities for N2Africa in Tanzania
49. Background information on agronomy, farming systems and ongoing projects on grain legumes in Ethiopia
50. Special Events on the Role of Legumes in Household Nutrition and Value-Added Processing
51. Value chain analyses of grain legumes in N2Africa: Kenya, Rwanda, eastern DRC, Ghana, Nigeria, Mozambique, Malawi and Zimbabwe
52. Background information on agronomy, farming systems and ongoing projects on grain legumes in Tanzania
53. Nutritional benefits of legume consumption at household level in rural sub-Saharan Africa: Literature study
54. N2Africa Project Progress Report Month 42
55. Market Analysis of Inoculant Production and Use
56. Grain legumes and fodder legume materials 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

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