Adaptation of improved climbing bean (*Phaseolus vulgaris* L.) technologies in the Ugandan highlands

Eva Thuijsman (930421830130)
MSc internship report (PPS-70424)

N2Africa, International Institute of Tropical Agriculture (IITA)
Plant Production Systems – Wageningen University
Supervisors: Esther Ronner, Joost van Heerwaarden
Examiner: Ken Giller

January 2017

Table of contents

Summary

N2Africa is a project that shows African smallholder farmers the potential benefits of nitrogen fixation by leguminous crops, and supplies production packages including seeds, fertilizer and a production manual. The goal of this project is to demonstrate improved legume technologies to enhance production of legumes and subsequent crops by African smallholder farmers. This internship study was part of the N2Africa project and took place in Uganda.

Data about the implementation of improved climbing bean technologies were collected by means of visiting farmers that received packages from N2Africa and established two trial plots on their own land: the *own* plots with current farmers' practices, and the *N2A* plot on which farmers tested the improved practices from the demonstration trial. Farmers were visited in the Ugandan districts Kapchorwa, Kabale and Kanungu. Two surveys were conducted among a random sample of farmers that received a package from N2Africa, on two separate household visits during and directly after the second rainy season of 2015: one mid-season (Oct-Dec, 2015) and one after harvest (Dec 2015 - Jan 2016). These surveys included quantitative and qualitative questions about climbing bean performance on the farmer's *own* plot and on his or her trial plot with N2Africa technologies (*N2A* plot), and about how the farmer valued the N2Africa package.

On the *N2A* plots, demonstrated improved practices were implemented most accurately in the Kabale and Kanungu. The planting practices (e.g. plant spacing and the number of plants per stake) on the *own* and *N2A* plot were only different from each other in Kanungu.

The practice of intercropping climbing beans (mainly with bananas) was very common, especially in Kapchorwa (around 80% of all plots) and less so in Kabale and Kanungu (around 40% of all plots). Planting beans in rows was the current practice in Kabale, but it was new in Kanungu. In Kapchorwa, half of the farmers already planted in rows.

Overall mean yields were below 1 t ha^{-1}. Yields were not different on *N2A* and *own* plots. Row planting or sole cropping did not result in larger yields. Only when farmers applied their own NPK, yields were significantly larger than when no inputs were applied. The TSP provided in the package, did not improve yields. *Nabe 12C* gave largest yields in Kanungu, but all varieties performed similarly in Kapchorwa. Variety *Nabe 12C* gave largest yields and was most appreciated by farmers in comparison to local and other improved varieties.

Low yields were mainly explained by heavy rains, damage by livestock, birds and rats, and low soil fertility. An additional major problem is the scarcity of staking material. Careful herding, the introduction of owls and birds, and the reuse of plastic waste for string staking may provide opportunities to mitigate these problems. Furthermore, some suggestions are proposed for future research and data collection by N2Africa.

Acknowledgements

First and foremost, many thanks to all farmers that I interviewed. Your hospitality was truly heart-warming. Many times I was offered delicious food and you were willing to walk great distances to your fields for my measurements. Thank you for teaching me how to use a hand-hoe, to peel and cook matoke, to eat tsenene and to slaughter chicken.

Thank you Esther Ronner, for letting me do this internship as part of your PhD work and for quickly replying to my messages from Uganda even though you were on maternity leave.

Thanks Joost van Heerwaarden, for discussing my report with me in detail and for introducing me to R, which was very useful. I learned a lot!

Gertrude Cherop, key tabon kabwisa for translating and for being such a great friend. I felt so happy and at home in the 'town of friends', Kapchorwa.

Innocent Byamugisha and Rogers Muhwezi, iwee bare munonga for translating for me and for accommodating me so comfortably with your families. It was amazing living with you in that incredibly beautiful landscape.

Justine Onyinge, thank you so much for taking me around while you were working in Kisoro and Kabale, together with Paul. I got a better impression of the scale of the N2Africa project and meeting you has been such an inspiration.

John Ssekamwa, I am grateful for your support and kindness throughout this experience. I remember very well how I looked my eyes out when you showed me the scenery of Kapchorwa and introduced me to the extension workers on my first day in Kapchorwa.

Thank you Peter Ebanyat, Millie, Racheal and Janet, for helping me get around from the IITA office in Kampala.

Thanks Ken Giller, for your inspiring lectures about farming in Africa and N2Africa, which made me want to go to Africa years ago! This dream came true and I cannot wait to go back again.

Gertrude Cherop.

Rogers Muhwezi.

Innocent Byamugisha and farmer's family.

1 Introduction

1.1 N2Africa in Uganda

The research-in-development project N2Africa shows African smallholder farmers the potential benefits of nitrogen fixation by leguminous crops such as beans. The project is led by Wageningen University and the International Institute of Tropical Agriculture (IITA), funded by the Bill and Melinda Gates Foundation. Biological nitrogen fixation can be an alternative or a supplement to inorganic fertilizers, thus limiting the necessity of external inputs (Giller, 2001). N2Africa is active in various African countries, with the bulk of activities taking place in Uganda, Ethiopia, Tanzania, Ghana and Nigeria. This internship study took place in Uganda.

Common beans (*Phaseolus vulgaris* L.) are a major staple crop in Uganda and an important contributor to daily caloric and protein intake (Mauyo et al., 2010). N2Africa aims to boost bean production by introducing improved bean varieties and production technologies. These improved beans are all climbing varieties, which often reach over 20% larger yields than common bush beans at the same production area because climbing beans grow taller along stakes (Katungu et al., 2016; Checa et al., 2006). Potential yields of climbing beans are 4 to 5 t ha^{-1} (and 3 t ha^{-1} for bush beans) under optimal conditions (CIAT, 2004). However, actual yields of Kenyan and Rwandan farmers are around 1.3 t ha^{-1} and 1.1 t ha^{-1} for climbing beans and bush beans, respectively (Ramaekers et al., 2012; Katungi et al., 2016).

Compared to bush beans, climbing beans have been shown to reduce soil, water and nutrient losses as a result of increased soil cover and more soil cover from litter (Gabiri et al., 2015). A disadvantage of climbing instead of bushy varieties, is a larger labour intensity because staking is required to lead the beans vertically (Ramaekers et al., 2013). Additionally, the larger biomass production of climbing beans comes with increased nutrient requirements from the soil (Sperling and Muyaneza, 1995).

Climbing beans require cooler temperatures, so they grow best at the higher altitudes of the Ugandan highlands (Wortmann et al., 1998), which are part of the East African Rift. Highlands are found in Eastern (the slopes of Mt. Elgon) and Southwestern Uganda. Therefore, the target areas for N2Africa to further develop climbing bean production are located in these regions: the districts Kapchorwa, Kabale and Kanungu.

The improved legume technologies include fertilizer application, improved spacing, long and strong stakes, timely weeding, few seeds per hole and few plants per stake. N2Africa supplies production packages to Ugandan farmers including seeds, inorganic fertilizer and a production manual.

In 2010, inorganic fertilizer and improved seeds were used on only 1.0% and 6.3% of Ugandan smallholder plots, respectively (Gollin and Rogerson, 2010). Inorganic fertilizer is applied at a rate of only 2.2 kilograms per hectare (data.worldbank.org, Feb 2016), making Ugandan fertilizer use one of the lowest globally (Swaibu et al., 2015). This reveals that there is a lot of room for improvement of access to inputs and for alternative measures to improve nutrient availability for better crop yield.

1.2 Study objectives

The aim of this internship study is to address the following research questions:

1. What are the local climbing bean production practices and do farmers implement the demonstrated improved practices?
This includes an assessment of farming practices in terms of input use, row spacing, plant spacing, the number of plants per hole and per stake, the number of stakes used, inter- or sole cropping, row or random planting, and the implemented staking method.
N2Africa demonstrates improved production practices on demonstration trials and distributes fertilizer and instruction leaflets. The question is whether farmers are picking up on any of the improved practices.

2. Do the improved varieties and improved practices lead to higher yields compared to local climbing bean production?
Farmers that visited the demonstration trials were instructed to prepare two climbing bean plots on their land: one with their traditional practices and one where they implement (some of) the practices shown by N2Africa. The yields of those plots were compared.

3. What are common constraints to bean production?
Farmers' explanations of factors influencing management practices and bean yield.

4 How do farmers evaluate the improved climbing bean varieties compared to the local varieties?
To identify which characteristics of the local and improved varieties farmers appreciated.

5. How can N2Africa improve its effectiveness?
An identification of major challenges and opportunities for climbing bean production in the Ugandan highlands, and a reflection on the research and extension methods that are used by N2Africa.

1.3 Report structure

The methodology of this internship study is explained in Chapter 2, which also contains background information about Uganda and the research areas. Chapter 3 covers the results of quantitative research on the traditional and supposedly improved practices implemented by farmers as well as the yield performance and a farmers' evaluation. These results are discussed in Chapter 4, and conclusions can be found in Chapter 5. Chapter 6 covers a range of topics related to main production constraints in the research areas, and it includes suggestions for the N2Africa project to improve its impact and functioning. The suggestions in Chapter 6 are based on my general impressions during field work and on non-directive interviews with farmers and N2Africa extension staff. Chapter 7 contains concluding remarks. The survey questions as well as additional results tables are attached as an Appendix.

2 Methodology

2.1 Study area

Data were collected between November 1st, 2015, and January 30th, 2016, in the Ugandan Eastern and Southwestern highlands in three districts: Kapchorwa, Kabale and Kanungu (shown on a map in Figure 1). These districts are divided into subcounties, which are again subdivided into parishes and villages. For Kapchorwa, the subcounties that were visited are: Chema, Munarya, Sipi and Tegeres. The subcounties that were visited in Kabale and Kanungu are Kashambya and Mpungu, respectively.

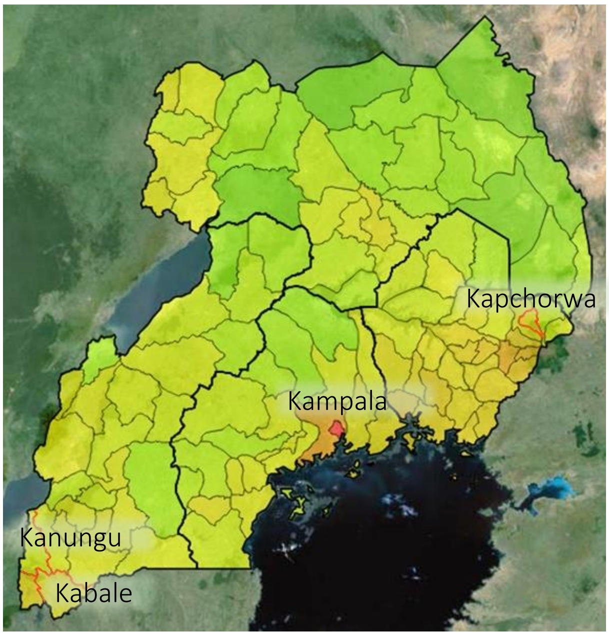


Figure 1 – Map of Uganda and its districts. The district of the study areas are marked with red boundaries. Districts are coloured based on population density: a darker shade of red means a larger population density.
Source: http://www.citypopulation.de/

2.1.1 Country background

Uganda lies in the equatorial East African highlands, with more than two-thirds of the country at 1000-1200 metres above sea level. It is densely populated with over 40 million people and about 200 people per square kilometre (World Population Review, November 2016). Uganda's tropical climate is moderate and does not vary much between regions, although the North-Eastern regions are generally drier (FAO, 2006). Rainfall is bimodal with peaks between March and May, and in September and November. The major dry spells occur in December, January, June, July and August, right after the two rainy seasons (Briggs and Roberts, 2010).

Ugandan agriculture is mainly characterised by quasi-subsistence agriculture. Trade is hampered by being landlocked, further stimulating self-reliance. More than 80% of the Ugandan population lives in rural areas, with subsistence agriculture as the principal source of income (UBOS, 2009/2010). In rural areas, there is a poverty rate of 34.2% (Gollin and Rogerson, 2010). Beans are grown by 53% of Ugandan farmers and they are the fifth most important food crop in Uganda (after highland banana [matoke], cassava, sweet potatoes and maize), accounting for 9% of the caloric intake (Haggblade and Dewina, 2010).

Smallholder farmers are the main food producers in Uganda, often growing multiple different crops together on plots that are close to the homestead (Gollin and Rogerson, 2010). Most smallholder farms are mixed: combining crop and livestock production. The average farm has a size of 1 to 5 hectares

(FAO, 2006) and is characterized by continuous production with little input and low yields (Woelcke, 2006).

Highland regions are the most densely populated areas of Uganda, after the Kampala region (Kanabahita, 2001). The rainfall pattern is slightly different in the Eastern and Southwestern region, causing the cropping seasons in the Southwest to start one month earlier. The study areas are found at similar altitudes, with similar average temperatures that barely vary during the year (Table 1).Bean production is more common in Southwestern Uganda than in Eastern Uganda, with 78% and 45% of farmers growing beans in the Southwestern and Eastern region, respectively (Haggblade and Dewina, 2010). Both regions are focal areas of N2Africa.

The districts of interest for this internship are Kapchorwa in the East, and Kabale and Kanungu in the Southwest. These districts are discussed in the next sections.

Table 1 – Characteristics of the study areas.

District	Annual rainfall[1] (mm)	Average temp.[1] (ºC)	Altitude[1] (masl)	Population density[2] (/km²)	Cropping season A[3]	Cropping season B[3]
Kapchorwa	1576	18.5	1800	312	Mar - Jul	Sep - Dec
Kabale	1313	20.7	2000	320	Feb - Jun	Aug - Nov
Kanungu	1222	18.9	1800	203	Feb - Jun	Aug - Nov

[1] climate-data.org (accessed March 2016); [2] citypopulation.de (accessed March 2016); [3] Ssekamwa and Byamugisha (personal communication, Nov 2015).

2.1.2 Kapchorwa

Kapchorwa district is located in the Eastern highlands of Uganda and lies on the slopes of Mt. Elgon (Figure 2), an extinct Pliocene volcano at the border of Uganda and Kenya. The study area includes the subcounties Tegeres, Chema, Munarya and Sipi, at increasing distance from the district capital: Kapchorwa town. They are located on the northern side of the mountain at an altitude around 1800 masl. These subcounties are situated slightly below the boundaries of the National Park Mt. Elgon and are characterised by rain-fed subsistence agriculture. Main food crops are highland bananas, cassava, maize, potatoes and beans; whereas coffee is the main cash crop (Bamutaze, 2010). The volcanic soil type is of medium to high productivity (NEMA, 2004; FAO, 2006).

Figure 2 – Landscape impression of the slopes of Mt. Elgon in Kapchorwa.

Average population density in Kapchorwa district is 312 inh./km^2 and almost 90% of the population lives in rural areas (UBOS, 2014; citypopulation.de, Mar 2016). The Sabiny (or Sebei) people constitute the main tribe inhabiting the northern slopes (Alinyo and Leahy, 2012), speaking the Kubsabini language. The average household size in the selected subcounties is 4.8 (UBOS, 2014). The population grows fast at a rate of 2.85% per year (UBOS, 2014), leading to land fragmentation, over-cultivation of plots and as a result lower soil fertility and lower soil holding capacity (Mukuve and Fenner, 2015). More than 67% of the population in the Eastern region of Uganda is illiterate (UBOS, 2012c)

Beans are predominantly used for home consumption, but many farmers sell part of their yield. Kapchorwa is connected to Mbale and Kampala by major roads (although still of low quality), but main markets for produce exist in the West, Northwest and on the Kenyan borders (Sassen et al., 2012; Mauyo et al., 2010). Farmers are much constrained by poor road quality and high transport costs (Gidoi, 2013; Mauyo, 2010).

2.1.3 Kabale and Kanungu

Kabale (Figure 3) and Kanungu (Figure 4) districts are found in Southwestern Uganda, near the border with Rwanda and Congo. The Bakiga tribe dominates the population in the research areas, speaking Rukiga language (UBOS, 2012a), and over 80% of the population lives in rural areas (UBOS, 2014). The study area covers the subcounties Kashambya in Kabale, and Mpungu in Kanungu. In Kanungu and Kabale, 30% and 53% of the population is illiterate, respectively (UBOS, 2012a,b) and almost a quarter of the population never attended school (UBOS, 2012a).

Average household sizes are around 4.6 for Kashambya and Mpungu subcounties (UBOS, 2014; 2012a; 2012b). Rapid population growth (with growth rates of 1.28 and 1.73 for Kabale and Kanungu, respectively [UBOS, 2014]) results in increased land fragmentation and it forces crop production towards steeper land areas, accelerating deforestation. Soil degradation is a big problem in the Southwestern highlands, with 90% of the land area affected by soil erosion as a result of overproduction and high intensity of rainfall (Nkonya, 2002; NEMA, 2001). Population pressure also limits the opportunities to leave land fallow for fertility restoration, rendering soils increasingly infertile (Ebanyat et al., 2010). The most dominant soil types in the Southwestern highlands are oxisols and utisols, which sometimes reduce the availability of phosphorus by fixing it (Nkonya, 2002).

Relative to other parts of the country, Western Uganda dedicates most land to bean production (UBOS, 2010). This despite average bean yields in Western Uganda being only 1.7 t ha^{-1} (UBOS, 2010), which is well below yield potential (Rockström and Falkenmark, 2010). In Kabale, beans are mainly produced during the first rainy season, whereas bean production in Kanungu occurs mainly in the second season (UBOS, 2010).

Dominant crops beside beans include maize, sorghum, millet, potatoes and highland bananas. Tea is a dominant cash crop. Most households rely on farming as their main or only source of income. However, market access is very low, for a large part because of the very bad road quality in the area (ADF, 2014). Especially Kanungu is very hard to reach with limited public transport and poor roads (Figure 5).

Figure 3– Landscape impression of Kabale district.

Figure 4 – Landscape impression of Kanungu district.

Figure 5 – Poor-quality road in Kanungu.

2.2 N2Africa demonstration and adaptation trials

N2Africa works through demonstration trials: fields in which different climbing bean varieties, staking methods and other input variations are shown to local farmers. These trials are planted and managed by N2Africa staff in collaboration with local farmers. The trials provide farmers with a basket of technology options from which they can decide for themselves what combination of methods and tools they want to implement. Farmers are invited to visit the trial on specific extension days, during which extension staff explains the demonstrated practices. On these occasions, farmers can choose a package containing seed of one of three or four climbing bean varieties and (if desired) inorganic fertilizer; enough material to cultivate a plot of approximately 10 x 10 m. The package also includes an instruction leaflet with the details of improved planting and staking methods.

Farmers can test these methods at home in so-called *adaptation trials* in their own fields. They are instructed to plant two climbing bean plots next to each other: one managed with the farmers' usual practice (the '*own'* plot) and one managed using the package and improved technologies demonstrated by N2Africa (the *N2Africa* plot, hereafter '*N2A'* plot).

This season (2015B), the provided fertilizer was TSP: Triple Superphosphate. TSP contains 45% P_2O_5, 15% Ca, and water, but no N in order not to interfere with the nitrogen fixation rate of legumes. N2Africa supports the use of fertilizers because they improve production without adding much to the labour required for bean production.

Table 2 shows the composition of the packages in the East and the Southwest. *Chesoy* and *Nyiramuhondo* are the same iron-enriched variety with different local names. For simplicity, *Nyiramuhondo* will also be called *Chesoy* in this report. *Kabale*, *Attawa* and *Katuna* are varieties that have been grown before in the research areas. They are local varieties to be tested with the improved production practices.

In Kapchorwa, three staking methods were shown in the demonstration trials: single staking, tripods, and string staking. In the Southwest, only single staking and string staking were shown. The recommended spacing and staking methods are shown in Figure 6 and 7.

Table 2 – Climbing bean varieties and recommended practices in the distributed packages in Kapchorwa, Kabale and Kanungu. Chesoy *and* Nyiramuhondo *are the same varieties with different names in different districts.* Nyiramuhondo *is called* Chesoy *in this report.*

Package composition		
Kapchorwa		*Kabale and Kanungu*
Nabe 12C	=	*Nabe* 12C
Nabe 12C + TSP	=	*Nabe* 12C + TSP
Chesoy	=	*Nyiramuhondo*
Chesoy + TSP	=	*Nyiramuhondo* + TSP
Kabale (local)		*Katuna* (local)
Kabale (local) + TSP		*Katuna* (local) + TSP
Attawa (local)		
Attawa (local) + TSP		

Recommended practices	
Row spacing	50 cm
Plant spacing	25 cm
# plants / hole	2
# plants / stake	4
# stakes / $4m^2$	16
Sole cropping	
Row planting	
Long and strong stakes	
Fertilizer and/or manure application	

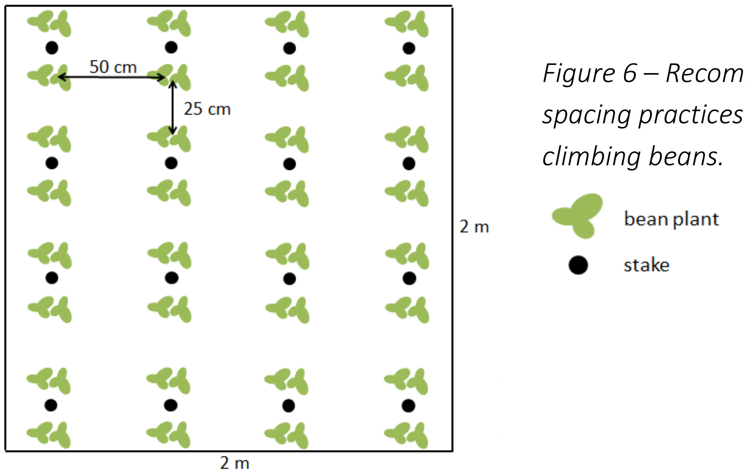


Figure 6 – Recommended spacing practices for climbing beans.

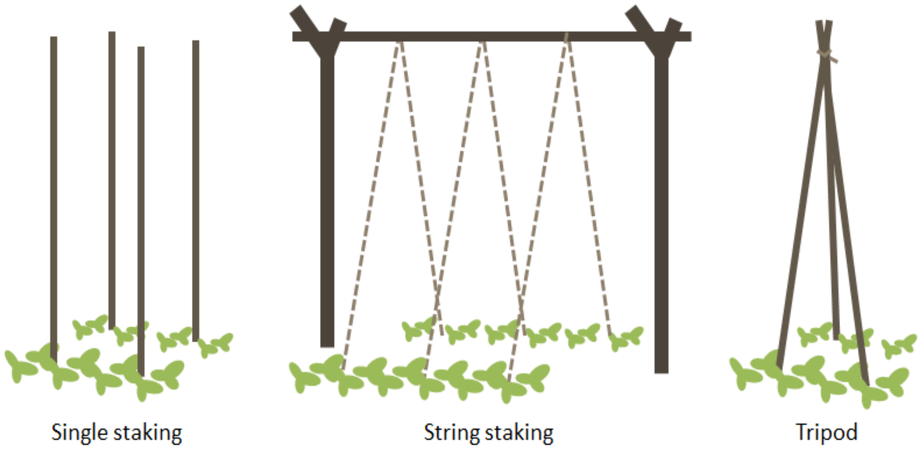


Figure 7 – Different staking practices for climbing beans. For string staking, extra strong supporting stakes are required.

2.3 Data collection

During extension days at the demonstration trials in the season 2015B, packages were distributed to 300 farmers in Kapchorwa, 106 farmers in Kanungu, and 51 farmers in Kabale. The farmers were requested to establish *adaptation trials* on their own fields.

Data were collected by means of interviewing farmers on two occasions: mid-season (survey part 1) and after harvest (survey part 2). The surveys can be found in Appendix 1 of this report. For each subcounty, farmers were selected randomly but with approximately equal numbers of farmers (if possible) from different parishes and at least five representatives per package. Because only a handful of farmers in the Southwest took packages without fertilizers, it was decided to focus only on packages *with* fertilizer in Kabale and Kanungu. Mid-season data were collected from 60 farmers in Kapchorwa, 30 in Kabale and 34 in Kanungu.

Only the farmers with *own* and *N2A plots* that were comparable in terms of placement and size were selected to return to after bean harvest for part 2 of the survey. Therefore, only 31 farmers in Kapchorwa, 10 in Kabale, and 21 in Kanungu were visited a second time. The results presented in this report are all based on data from farmers that completed part 1 and part 2 of the survey. Results from the total population sample (farmers visited at least for survey part 1) are included in the Appendix. During this second visit, the bean yield was weighed. Some farmers had consumed part of their produce, and they would estimate the weight of the consumed beans.

Average yields (kg seed per ha) for *N2A* and *own* plots in Kapchorwa were calculated based on measured seed weight plus estimated seed weight consumed, and measured plot size. Sometimes beans were not threshed before weighing. Esmaeilzadeh and Aminpanah (2015) described dry pod yield and seed yield for *P. vulgaris* under different fertilization, weeding and planting treatments. The average seed/pod weight ratio was 0.85 (SE=0.01), so this was used as a weight conversion factor to estimate seed yield from pod yield.

Harvest in the Southwest was delayed until February, which implicated time constraints: part 2 of the survey had to be performed before harvest and questions with regard to bean performance were answered based on present production observations and expected yield by the farmers. After harvest, some N2Africa extension workers returned to these farmers for a third time to weigh the yield. However, the yield data obtained from Kabale were considered unreliable (inaccurate weighing and yield estimations by farmers) and they were therefore not included in this report.

The survey was constructed from the baseline adaptation trial surveys from N2Africa with additions from Esther Ronner as part of her PhD research for Wageningen University. The survey included questions about general household characteristics and qualitative viewpoints towards climbing bean production. Additionally, quantitative measurements were taken in the climbing bean fields on plot size, plant spacing, row spacing, plants per hole, plants per stake, number of stakes on 4 m^2, and length of stakes. The Open Data Kit (ODK) tool for mobile data collection was used to digitalize the survey form and enter responses and measurements directly on a tablet during the interview.

In Kapchorwa, a local woman living in Kapchorwa town, helped with translation. In Kabale and Kanungu, the survey questions were translated by local N2Africa extension staff.

2.4 Qualitative methods

The farm visits and informal conversations with farmers and N2Africa staff, resulted in a broad overview of main problems and concerns perceived by farmers with regard to legume production. The constraints and challenges described in Chapter 5 of this report are based on these unstructured interviews and general impressions. The suggested measures to approach these problems have not yet been specifically tested in the research areas but could be considered by the N2Africa team.

2.5 Statistical analysis

A descriptive statistical analysis of the survey data was performed using *R* software version 3.3.2 (2016). A one-way ANOVA was used to reveal differences and similarities in climbing bean production on the *own* and *N2A* plots, between different varieties and in the different study areas. A Chi-square test was performed to check for differences in fertilizer use between and within districts and plot types (*N2A* or *own*). Effects of management practices on bean yields were analysed with linear mixed models of the following structure: *yield ~ (fertilizer + row planting + variety + intercropping) * plot type* $_{N2A\ or\ own}$ *+ (random effect: farm location).* Significant effects were then tested with Tukey's HSD Posthoc Test.

A paired Wilcoxon test was used to reveal whether varieties from N2Africa packages received better evaluation scores from farmers than the variety they planted on their *own* plots. Production practices on the *N2A* and *own* plots were compared to the N2Africa's recommendations using a two-sided one sample t-test.

Significant differences of means were calculated at a significance level of <0.05.

3 Results

The results presented in this section are all based on data from farmers that completed part 1 and part 2 of the interview. Results from the total population sample (farmers visited at least for survey part 1) can be found in the Appendix.

All farmers planted two plots on their own land: their *own* plots represent traditional climbing bean farmers' practices, and *N2A* plots were planted using improved practices from the demonstration trials. In the next sections, input use, management practices and production levels of these plots are presented and compared.

3.1 Input use

In Kapchorwa, the farmers included in this study had received packages with and without fertilizer, whereas in Kabale and Kanungu, only farmers that received packages *with* fertilizers were selected for interviews (the sample size of farmers with packages without fertilizer was too small).

Input use differed among the three districts (*N2A* plots: P=0.009, *Own* plots: P=0.02, tested with a Chi-square test). Only in Kabale and Kanungu, input use was significantly different on the *N2A* and *own* plots (Kabale: P<0.001, Kanungu: P<0.001, tested with a Chi-square test): fewer inputs were used on the *own* plots.

In Kabale and Kanungu, the applied inorganic fertilizer was always the TSP provided by N2Africa. Some farmers (in all three districts) divided the TSP from the package over their *N2A* and *own* plot. In Kapchorwa, some farmers used their own NPK, CAN or DAP. The exact amount of applied fertilizer was not measured, but farmers indicated that they used very small amounts. Table 3 shows the input use by farmers.

In Kabale and Kanungu, none of the *own* plots received any inputs, except for two in Kabale. The general impression was that households in the Southwestern study areas were poorer than in Kapchorwa and that fertilizer use was highly uncommon.

Table 3 – Numbers of farmers using inputs on their own *plots (absolute values).*

District	Plot type	Inorganic fertilizer			Inorganic fertilizer + animal manure			Animal manure	No inputs	N
		TSP[1]	*Other[2]*	*Total*	*TSP[1]*	*Other[2]*	*Total*			
Kapchorwa	N2A	12	4	15[3]	3	1	4	3	9	31
	Own	3	5	8	3	1	4	3	16	31
Kabale	N2A	7	0	7	1	0	1	2	0	10
	Own	2	0	2	0	0	0	0	8	10
Kanungu	N2A	14	0	14	7	0	7	0	0	21
	Own	0	0	0	0	0	0	6	15	21

[1] *TSP is the fertilizer provided by N2Africa.*

[2] *Other fertilizers used by farmers were NPK, CAN and DAP.*

[3] *One farmer used a combination of TSP (from N2Africa) and her own NPK.*

3.2 Intercropping

Figure 8 – Climbing bean /banana intercrop.

Intercropping was very common in Kapchorwa, where around 85% of the *N2A* and *own plots* was intercropped. In the Southwestern region, intercropping occurred less frequent but was still common (see Table 4). Climbing beans were often grown in banana fields (Figure 8). Figure 9 shows the crop combinations and their relative occurrence in the different study areas. In almost all cases, farmers planted both their *N2A* and *own* plots as either an intercrop or sole crop.

Reasons for intercropping or sole cropping climbing beans were similar for the *N2A* and the *own* plots. In by far the most cases, intercropping was implemented to use land efficiently ("there was space here between the other crop") or because there was no open land available. Few farmers mentioned that legumes can benefit the intercrop, or that it was tradition. If farmers chose not to intercrop, this was in most cases to avoid crop competition for nutrients and light, and/or because N2Africa had demonstrated sole-cropped climbing beans.

Table 4 – Proportion of N2A and own plots that are intercropped.

District	Proportion of plots intercropped				Number of times these *N2A* and *own* plots were located on the same field
	N2A	*N*	*Own*	*N*	
Kapchorwa	87 %	31	84 %	31	90%
Kabale	30 %	10	30 %	10	100%
Kanungu	38 %	21	24%	21	86%

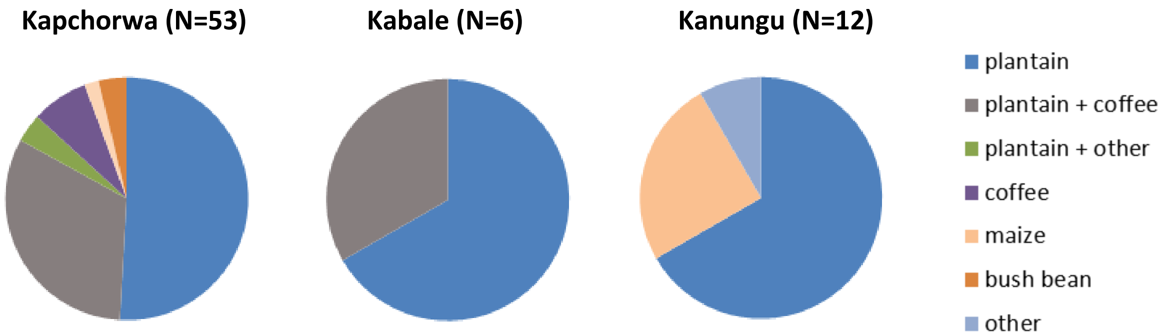


*Figure 9 – Relative occurrence of crops that were intercropped with climbing beans (*N2A *plus* own *plots).*

3.3 Row planting

In Kapchorwa, about half of all plots was planted in rows. In Kabale, the row planting practice was applied on all plots. In Kanungu, only a quarter of the *own* plots was planted in rows, but almost all of the *N2A* plots; a large difference. Table 5 shows the proportion of plots planted in rows in all study areas. Row planting also occurred in intercropped plots with randomly planted intercrops such as bananas. The row simply continued behind the banana plant.

Various reasons were given for planting in rows or not, as shown in Figures 10 and 11. Row planting was mainly practiced because it was demonstrated by N2Africa and because it made it easy to pass through the field for crop management practices. Planting without rows is the traditional method and is considered easier and faster during planting. A trade-off existed between labour at planting and labour later in the seasons for weeding and staking.

With regard to *N2A* and *own* plots, many more farmers in Kanungu remarked that they planted in rows because this was taught in the demonstration trial (*N2A*: 82%; *own*: over 63%), compared to farmers from Kapchorwa and Kabale (*N2A*: 35%; *own*: 16% in both areas).

Over 80% of farmers in Kanungu remarked that they planted in rows on their *N2A* plots because this was taught in the demonstration trial, whereas only around 35% of farmers in Kapchorwa and Kabale mentioned that as a reason.

Table 6 shows the number of farmers applying sole cropping *and* row planting in the same plot (as was recommended by N2Africa). In Kapchorwa, only very few farmers combined those two practices (most plots were intercropped). In Kabale, 7 out of 10 farmers applied both practices on their *N2A* as well as their *own* plots. In Kanungu, there is a larger difference between the level of compliance with N2Africa's recommendations on the *N2A* and *own* plots: 13 out of 21 farmers applied sole and row cropping on their *N2A* plots, and 6 out of 21 on their *own* plots.

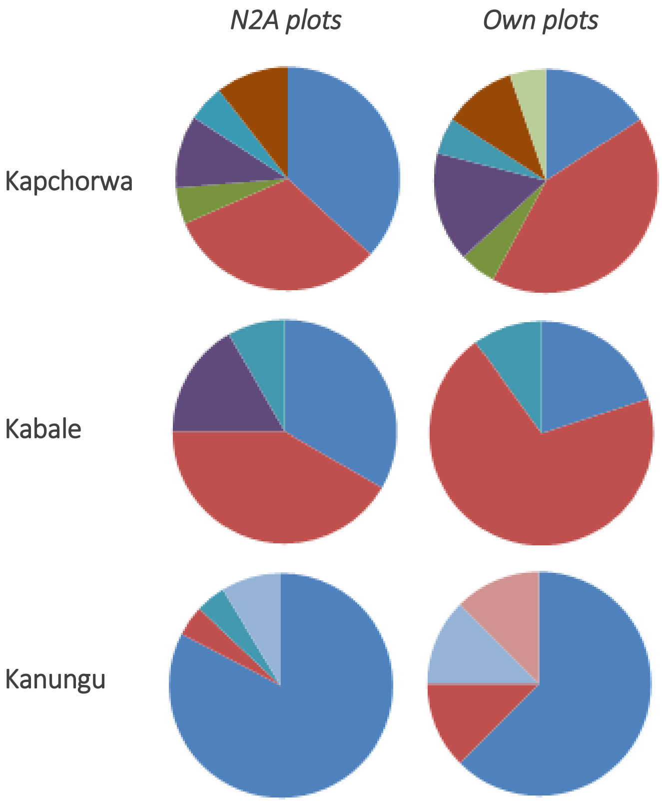
Table 5 – Proportion of N2A *and* own *plots that are planted in rows.*

District	Proportion of plots planted in rows				Number of times these *N2A* and *own* plots were located on the same field
	N2A	*N*	*Own*	*N*	
Kapchorwa	55 %	31	55 %	31	67%
Kabale	100 %	10	100%	10	100%
Kanungu	100%	21	33 %	21	100%

Table 6 – Number of farmers applying sole cropping as well as row planting (recommended by N2Africa).

District	Number of farmers applying sole cropping as well as row planting (recommended)				Number of times these *N2A* and *own* plots were located on the same field
	N2A	*N*	*Own*	*N*	
Kapchorwa	2	31	4	31	2
Kabale	7	10	7	10	7
Kanungu	13	21	6	21	6

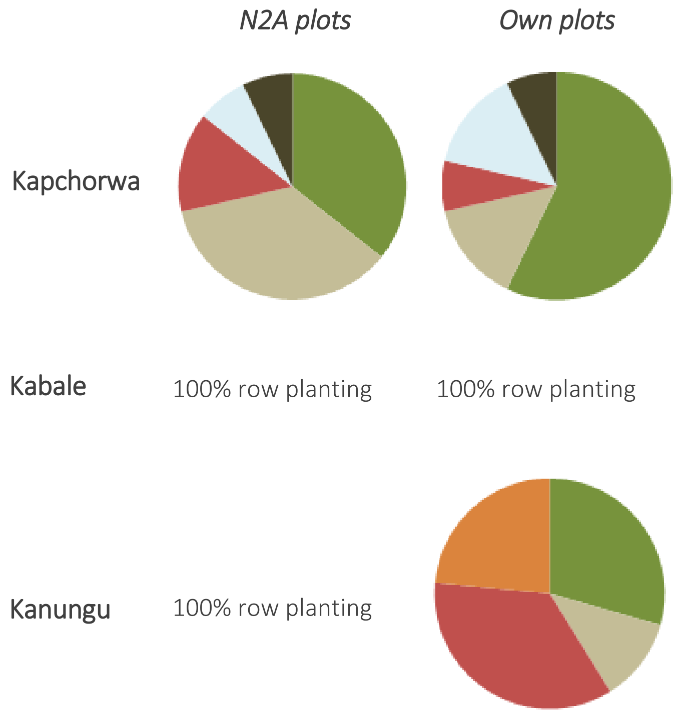
Reasons to plant in rows



Number of farmers planting in rows			
	N2A	*Own*	*N*
Kapchorwa	17	17	31
Kabale	10	10	10
Kanungu	21	7	21

Figure 10. Reasons for planting in rows on the own *and* N2A *plots, and the relative number of times they were mentioned by farmers.*

Reasons not to plant in rows



Number of farmers not planting in rows			
	N2A	*Own*	*N*
Kapchorwa	14	14	31
Kabale	0	0	10
Kanungu	0	14	21

Figure 11. Reasons not to plant in rows on the own *and* N2A *plots, and the relative number of times they were mentioned by farmers.*

3.4 Traditional planting and staking on the *own* plots

Analysis of the planting practices on the *own* plots of farmers revealed that farmers' practices are slightly different in the study areas. Row spacing in Kapchorwa is wider, with a larger number of plants per hole and with fewer and shorter stakes compared to the Southwestern region (Figure 12). In Kanungu, broadcasting seeds was relatively common in the *own* plots. This is visible in the data as few plants 'per hole' and smaller plant spacing. Data on plant spacing in Kapchorwa are missing due to measurement errors.

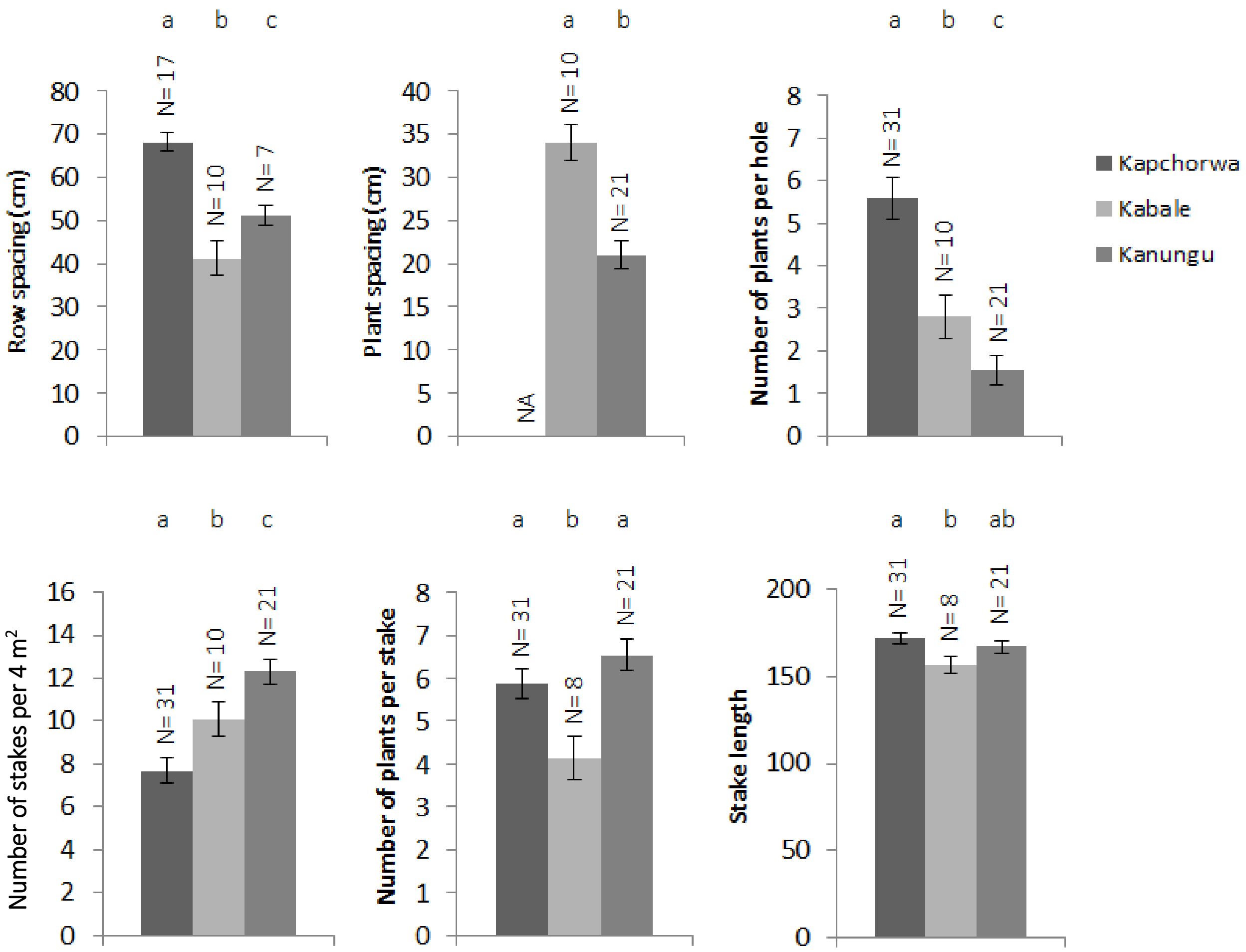


Figure 12 – Traditional climbing bean production methods on the own *plots in Kapchorwa, Kabale and Kanungu. Significant differences are marked with letters above the error bars.*

In all plots in all study areas, the method used to support the climbing beans was single staking, except for one farmer using tripods. Three farmers experimented with string staking on a very small part of their plot. Farmers commented that single staking was a practice they were used to, but that they are willing to try other methods that require less stakes because staking material is very scarce. Farmers were interested in string staking for that reason, but did not apply this because strings were too expensive and the construction too labour intensive. Besides, the expensive sisal strings can only be used for one season.

3.5 Implementation of the demonstrated improved planting practices

The practices on the *N2A* and *own* plots were compared to the recommended practices (Table 7) to see to what extent farmers implemented the practices that were shown at the demonstration trials and on the instruction leaflets (as provided by N2Africa). The Southwestern study areas implemented the demonstrated practices most accurately on their *N2A* plots.

Practices on the *own* plots were significantly different from the recommended practices in all cases, except for row spacing, the number of plants per hole and the number plants per stake in Kabale, and the number of plants per hole in Kanungu.

Production practices in the *N2A* and the *own* plots were compared to see whether the adopted recommended planting practices were truly different from the traditional farmers' practices. Significant differences were only found in Kanungu, where there was wider plant spacing (P<0.001), a larger number of plants per hole (P<0.01), a larger number of stakes per 4 m^2 (P=0.05) and a smaller number of plants per stake (P=0.001) on the *N2A* plots compared to the *own* plots. In Kabale, only the number of stakes used was different for the different plot types (P<0.001). Other than that, planting practices on the *N2A* and *own* plots Kapchorwa and Kabale were statistically the same.

Table 7 – Climbing bean production practices on the farmers' N2A *and* own *plots. Significant differences between the implemented practices and the practices recommended by N2Africa are indicated: (Sig.); '***' for P<0.001; '**' for P<0.01; '*' for P<0.05, resulting from a two-sided t-test.*

	Row spacing (cm)						Plant spacing (cm)					
Suggested:	*50 cm*						*25 cm*					
	N2A			*Own*			*N2A*			*Own*		
District	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*
Kapchorwa	66 ± 2	17	***	68 ± 2	17	***	NA			NA		
Kabale	52 ± 4	10		47 ± 3	10		28 ± 1	10		31 ± 3	10	**
Kanungu	48 ± 2	21		42 ± 3	7	**	30 ± 1	21	**	20 ± 2	21	*

	Number of plants per hole						Number of stakes on 4 m^2					
Suggested:	*2*						*16*					
	N2A			*Own*			*N2A*			*Own*		
District	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*
Kapchorwa	4.6 ± 0.3	31	***	5.3 ± 0.3	31	***	8 ± 0	31	***	8 ± 1	31	***
Kabale	2.3 ± 0.2	10		2.4 ± 0.6	10		17 ± 2	8		12 ± 1	10	**
Kanungu	2.3 ± 0.1	21		1.6 ± 0.4	21		15 ± 1	21		13 ± 1	21	**

	Number of plants per stake						Stake length			
Suggested:	*4*						*long*			
	N2A			*Own*			*N2A*		*Own*	
District	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*μ ± SE*	*N*
Kapchorwa	4.8 ± 0.4	31	*	5.6 ± 0.4	31	***	177 ± 5	31	170 ± 4	31
Kabale	3.3 ± 2.3	8	*	3.7 ± 0.7	8		166 ± 9	8	152 ± 7	8
Kanungu	4.1 ± 0.2	21		6.2 ± 0.5	21	***	167 ± 3	21	168 ± 4	21

In Kapchorwa and Kabale, stake availability was most limiting. There is much room for improvement in the number of stakes used, but reaching the recommended 16 stakes per 4 m^2 is hardly achievable because stakes are too scarce.

Row spacing in Kapchorwa was very large in the *own* and *N2A* plots, and compensated for by a higher number of plants per hole. In Kapchorwa, only 59% of the farmers applied row planting on their *N2A* plots, whereas in the Southwestern region all farmers adopted this practice (with one exception).

During the demonstration trials, the importance of good weeding was stressed. In all study areas, the average number of weeding interventions was around 1.85 for *N2A* and *own* plots both. Only the *own* plots in Kanungu were weeded less often: 1.4 times on average.

3.6 Climbing bean yield

In Kabale and Kanungu, data about seed quantity planted and yield were not first-hand, and data from Kabale were considered unreliable. Therefore, only yields in Kapchorwa and Kanungu are discussed in this report. Bean yields were weighed if possible, but in some cases farmers had already consumed part of their produce. In those cases, they estimated how much they had consumed. Yields were partly estimated in 38% of all cases.

3.6.1 Field sizes and quantity of seed planted

Plot sizes were rather variable (Table 8). Differences between districts can be caused by different seed quantities in the N2Africa packages per area. In Kapchorwa, each package was supposed to contain 0.5 kg seed, but some farmers explained that they had received one and a half or two packages of seed. In the Southwest, packages contained about 0.360 kg seed, but one person received less. Other differences are caused by varying plant spacing.

The seed provided by N2Africa was enough for an area up to 100 m^2, but some plots were larger than that. Some farmers insisted that they only used seed from the package, others complemented the seed from the package with their own seed of the same variety.

Table 8 – Plot sizes and seed quantities planted.

District	Plot type	Average plot size (m^2) ± SE (measured)	Average seed quantity planted (kg) ± SE (reported by farmers)
Kapchorwa	N2A	135 ± 27	0.66 ± 0.16
	own	140 ± 19	1.50 ± 0.38
Kabale	N2A	68 ± 21	NA
	own	97 ± 21	NA
Kanungu	N2A	35 ± 4	0.35 ± 0.005
	own	40 ± 5	0.63 ± 0.07

Yields (as presented in section 3.7.2) were not corrected for the quantity of seed planted, because density effects are unknown.

3.6.2 Grain yields

Mean yields were 810 (SE = 103) kg ha^{-1} for Kapchorwa, and 739 (SE = 100) kg ha^{-1} for Kanungu. Yields were not higher on *N2A* plots than on *own* plots in both regions. It was already revealed that planting practices on the *own* and *N2A* plots were only significantly different from each other in Kanungu (see section 3.6), but this has not resulted in a yield difference. Other factors such as the larger proportion of plots planted in rows or as sole crops on the *N2A* plots than on the *own* plots, have not resulted in a yield difference between the two plot types.

The application of TSP (as was provided and recommended by N2Africa) did not result in higher yields than when no inputs were used at all. Only when farmers applied their own NPK, yields were higher compared to plots without any inputs ($P<0.05$), as shown in Figure 13a. The use of organic manure or a combination or organic and inorganic fertilizer did not influence yields.

In Kapchorwa, the effect of planting in rows on yield was almost significant ($P=0.0549$) (Figure 13b), but not in Kanungu. Yields were also not affected by intercropping or sole cropping.

Only in Kanungu, improved variety *Nabe 12C* gave higher yields than the local variety *Katuna* ($P<0.05$) and – with larger uncertainty – than *Chesoy* ($P<0.10$), as shown in Figure 13c. Local varieties *Kabale* and *Katuna* had very low yields, but they were underrepresented in the sample population.

The yield on the only plot with tripods was below 40 kg ha^{-1} because cows had been damaging the plot very much.

The highest yield was 4.95 t ha^{-1} (three quarters of this grain yield was estimated by the farmer after consumption) on an *N2A* plot in Kapchorwa with variety *Nabe 12C*, where NPK was applied instead of the provided TSP, along with insecticides and irrigation during the early drought period. This plot was weeded three times whereas most farmers weeded only two times.

In Kanungu, the highest measured yield was only 2.43 t ha^{-1}, on a row-planted *own* plot with the *Mubano* variety, where no inputs were applied and which was weeded only once.

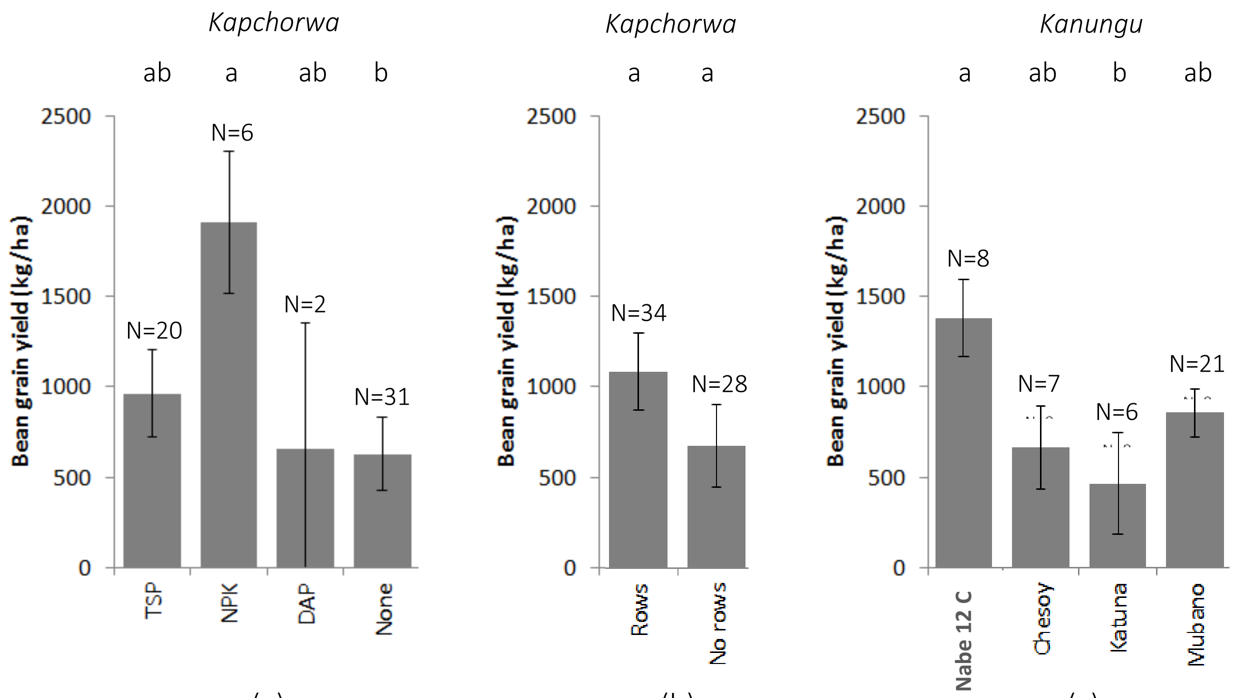


Figure 13 – Bean yields (predicted means) with standard errors for (a) different types of inorganic fertilizers in Kapchorwa, (b) plots planted either or not in rows in Kapchorwa, and (c) different bean varieties in Kanungu. Predicted means result from a linear regression model that was corrected for farm location. Significant differences are marked with letters above the bars.

3.6.3 Yields explained by farmers

Farmers experienced different problems during climbing bean production that (partly) explained yields. Figure 14 shows the intensity of production problems as perceived by farmers in all study areas. Heavy rain and low soil fertility were mentioned by about half of the farmers in each district as an important additional cause of low yields.

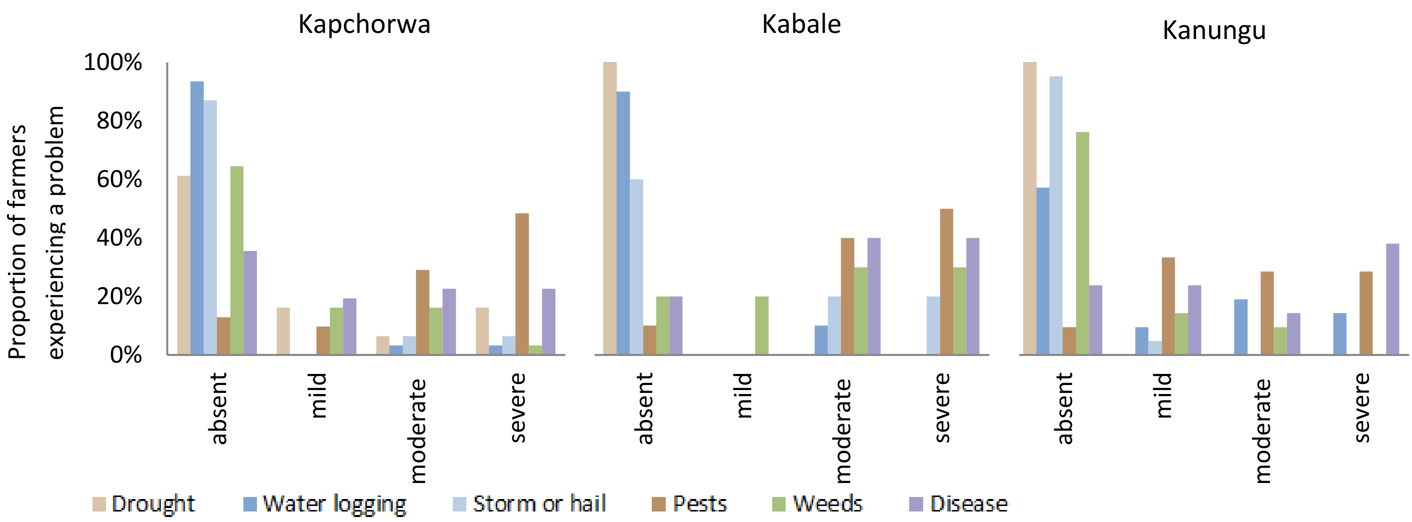


Figure 14 – Severity of climbing bean production problems experienced by farmers. Numbers of farmers: Kapchorwa N=31; Kabale N=10; Kanungu N=21.

Pests and diseases were most often the cause of severe damage to the bean plots. Pests included insects and animals. In Kapchorwa, cows, chickens and aphids were most common pests; the livestock being much more destructive than the aphids. In Kabale and Kanungu, birds and rats were the biggest problems. The relative occurrence of specific pest species in the different study areas is depicted in Figure 15.

Upon asking farmers about common reasons for obtaining low yields in general and for legumes specifically, more than half of the farmers mentioned late planting and weeding.

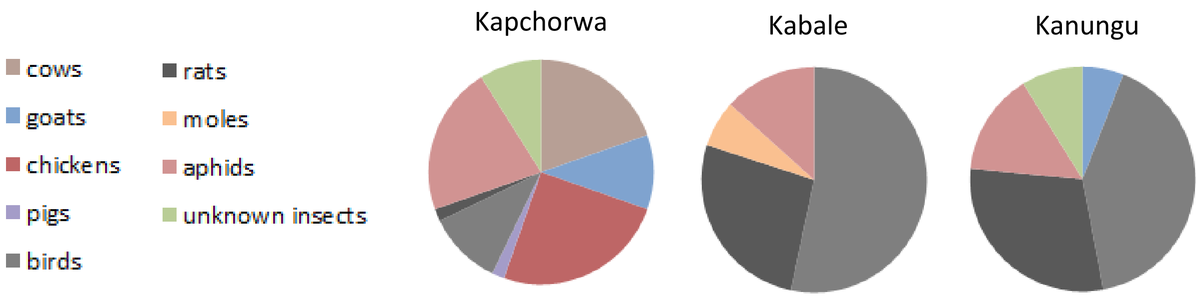


Figure 15 – Relative occurrence (number of times mentioned by farmers) of pests affecting climbing bean production in the different study areas. Numbers of farmers: Kapchorwa N=31; Kabale N=10; Kanungu N=21.

Many farmers chose a package that contained fertilizer. In the demonstration trials, the control plot without fertilizers generally performed clearly worse than the plots with fertilizer. Only a few farmers mentioned the application of TSP and/or manure on one of their plots as a reason for yield differences: other factors (heavy rains and pests) were considered more important. Many farmers explained that the effect of TSP was only seen during germination (quicker development of young plants) and sometimes later in plant vigour, while not contributing to better pod growth compared to plots without fertilizers. Still, farmers indicated that they would like to use fertilizers again because they know that it should improve yields, even after explaining that it did not influence their own grain yield. After the survey, many farmers commented that they wished that N2Africa provided free fertilizer again, because it was too expensive for them. They are willing to use fertilizer, but only if it is provided *very* cheaply.

3.7 Farmers' evaluation of bean varieties

Farmers were asked to give a score of 1 to 5 to various characteristics of the bean variety they planted from the N2Africa package and the variety they planted on their *own* plot. The most common varieties planted on the *own* plots were *Attawa* (in Kapchorwa) and *Mubano* (in Kanungu). *Table 9* shows which varieties received better evaluation scores than other varieties.

Table 9 – Farmers' evaluation of climbing bean varieties. 'A > B' signifies that variety A received a better evaluation score than variety B. Scores were tested for significant differences with a Wilcoxon signed-rank test.

Evaluation criterion	Comparison
Grain size	*Nabe 12C* > *Attawa* (P<0.01; N=12) *Nabe 12C* > *Mubano* (P<0.01; N=8) *Katuna* > *Mubano* (P<0.05; N=6)
(Expected[1]) grain yield	*Nabe 12C* > *Attawa* (P<0.05; N=12)
(Expected[1]) fodder yield	*Nabe 12C* > *Mubano* (P<0.01; N=8) *Chesoy* > *Mubano* (P<0.05; N=7)
Animal tolerance	*Nabe 12C* > *Mubano* (P<0.01; N=8) *Chesoy* > *Mubano* (P<0.05; N=6) *Katuna* > *Mubano* (P<0.01; N=6)
Insect tolerance Drought tolerance Disease resistance Weed resistance Maturity date Input costs Labour costs Input availability Marketability	No significant difference

[1] Farmers in Kabale and Kanungu were interviewed about their yields before they harvested. Yield expectations based on field observations determined their evaluation scores.

Farmers were generally very content with *Nabe 12C*, because this is a vigorous variety providing a lot of residue. Its large seed size, black-and-white colour and its taste were also highly appreciated.

Some farmers received packages with local varieties: *Attawa, Kabale* (both in Kapchorwa) and *Katuna* (in Kabale and Kanungu), to test whether these varieties would perform better with demonstrated practices. Based on the impressions of farmers, *Katuna* in some cases outperformed *Mubano. Attawa* and *Kabale* from the package did not perform better with improved than with traditional management.

4 Discussion

4.1 Local production practices and implementation of improved practices

Farmers were asked to use their usual practices on their *own* plots and the demonstrated improved practices of their liking on *N2A* plots in the same field. A comparison between the two plot types revealed that the management practices on the *N2A* and *own* plots turned out very similar, especially in Kapchorwa and Kabale.

In Kapchorwa and Kabale, planting practices (like plant spacing and the number of stakes used) were the same on the *N2A* and *own* plots. Only in Kanungu, plant spacing, the number of plants per hole, the number of stakes, and the number of plants per stake were different between the *own* and *N2A* plots (Section 3.5). Besides, all *N2A* plots in Kanungu received fertilizer but none of the *own* plots. In Kapchorwa, half of the *own* plots received fertilizer (Table 3). In all study areas, the large majority of farmers planted their *N2A* plots and their *own* plots both either or not as a sole crop (Table 4), or in rows or not (Table 5).

Farmers were asked to explain why they planted like they did, but most answers were of the nature 'easy planting and passing'. Farmers would regularly say that they had the same reasons for planting practices for their *own* plots as they had just explained for their *N2A* plots. It is unclear whether farmers followed any improved practices on their *own* plots based on recommendation or by tradition, as this was not asked specifically in the survey. This makes the *own* plots more difficult to interpret: do they show that local planting practices are similar to recommended practices, or that farmers tried some improved planting practices on their *own* plots?

With regard to row cropping, it was a bit clearer whether farmers applied it because of tradition or recommendation. In Kanungu it was clear (from Figures 10 and 11 and general impressions) that broadcasting was tradition and that row cropping was a new practice for beans. In Kabale, row cropping was already the common practice. In Kapchorwa, row cropping was new for some farmers, and common for others. The answers given to the open survey question about reasons revealed the most prominent reasons and not necessarily all reasons farmers may have had. Farmers that mentioned 'easy planting' may have done so because of tradition or because this was taught at the demonstration trial. In follow-up research, the researcher should make sure to enquire more specifically about this.

Most farmers had very practical reasons for either intercropping or sole cropping, and they applied the same management in both their plots in almost all cases (Table 4). In most cases, beans were placed in banana fields to use the space between the banana plants, or because no open land was available. Sole-cropped climbing beans are usually more productive than intercropped climbing beans (Ruganzu, 2014) but this was not confirmed by yield data from this study. Sole cropping was shown in the demonstration trials, although in many cases, farmers had no open land available for their beans. The landscape in the Southwestern region appeared more suitable for sole cropping than Kapchorwa because the landscape in Kapchorwa was more fragmented. Beans were most commonly intercropped with banana plants. There is space between the banana plants, so adding a crop is a bonus as compared to not producing anything. The beans do not appear to have negative effects on the bananas, but instead provide some nitrogen and mulch. Research by N2Africa on the effects of legume intercropping on banana production started directly after this internship study. Legumes other than climbing beans may be more worthwhile if optimal legume production is not the goal, to save the labour used for staking.

Only very few farmers tried another staking practice than single staking (on a small part of their plot). Farmers mentioned that they did not understand the benefits of tripods, saying that it is just extra work tying the tops of stakes together. The message that tripods are steadier had not come across. Many fields were hardly passable because the single stakes had fallen. Especially in the Southwestern study areas (where the fields were more open than in Kapchorwa) wind can affect the beans easily and tripods could be useful. Research for N2Africa in Kenya by Woomer (2012) revealed higher climbing bean yields on tripods compared to string staking and single staking (lowest yields).

4.2 Effects of management on yield

Overall mean climbing bean yields were below 0.8 t ha^{-}1, which is well below the yield potential of 4 to 5 t ha^{-1} (under optimal management and with inputs of fertilizer and pesticides) (Checa et al., 2006), but also below farmers' yields as measured in Rwanda and Kenya, which were around 1.3 t ha^{-1} (Ramaekers et al., 2012; Katungi et al., 2016).

The results clearly show that the *N2A* plots did not give higher climbing bean yields than the *own* plots, which can be explained by the similarities in management practices on the *N2A* and *own* plots (as discussed in section 4.1). The differences in planting practices and fertilizer application on the *N2A* and *own* plots in Kanungu did not translate to a yield difference.

A factor that did influence yield was the type of fertilizer used in Kapchorwa (Figure 13a). Best yields were obtained when farmers applied their own NPK inorganic fertilizer. NPK was not applied in Kanungu or Kabale. Remarkably, the application of any fertilizers (inorganic or organic) other than NPK, did not significantly result in higher yields than when nothing was applied. NPK contains nitrogen, and may therefore decrease the amount of nitrogen fixed because the beans no longer need atmospheric nitrogen if they can get it from the soil (Hardarson et al. 1984). Although higher yields are of course favourable in terms of nutrition or sales, a reduction in nitrogen fixation is the opposite of N2Africa's goal to improve the contribution of atmospheric nitrogen to the soil.

In Kanungu, variety *Nabe 12C* had significantly higher yields than *Katuna* and (almost significant) *Chesoy* (Figure 13c).

There was an indication that row planting gave slightly higher yields than random planting in Kapchorwa (almost significant).

It needs to be stressed that yield data were not entirely reliable because 38% of all farmers had consumed part of their bean produce and estimated the weight of this amount. Additionally, plot sizes and shapes were very variable, which may also have reduced the reliability of yield data.

4.3 Constraints to bean production

Management practices like the ones recommended by N2Africa were not often mentioned by farmers as an explanation for the obtained yields. A more common explanation was that the effects of management practices were largely overridden by more influential factors such as adverse weather events, damage by pest insects and animals, or plant diseases.

Farmers indicated that strong rains destroyed young bean plants and spread fungal diseases. FAO/GIEWS data (2015) confirmed that rainfall was very heavy this season 2015B, putting standing crops in particular at great risk of damage. The uncommon precipitation pattern of this season was attributed to the climate phenomenon *El Niño* (UNMA, 2015). Season 2015B was delayed and started in October rather than September, and continued until the end of December in Kapchorwa and January in the Southwest. Water logging was not very common, but farmers observed that the rain struck the flowers from the bean plants, damaging them and facilitating the development of blight. Bean plots were also heavily affected by animals; in Kapchorwa mainly by unrestricted cows and chickens, and in

Kabale and Kanungu by rats and birds. These animals destroyed complete plots in some cases. Any effects of management practices may reveal themselves in years with more stable weather or when pest animals are restricted.

Some farmers complained that the packages were delivered too late. Farmers in all districts mentioned that they would prefer receiving the packages earlier so that they can use a preferred (open) plot for their beans, plan the crop distribution across their fields more timely and plant as soon as favorable conditions occur. Especially in Kabale (no yield data available) the *own* plots were planted much earlier than the *N2A* plots, resulting in only few truly comparable plots. Many farmers remarked that late planting and weeding were reasons for obtaining low legume yields. Upon asking farmers about common reasons for obtaining low yields in general and for legumes specifically, more than half of the farmers mentioned late planting and weeding. Figure 15 illustrates this issue: it is a picture of two adjacent plots in Kanungu, where the one on the right received no management besides planting and very late staking, and the one on the left (with better bean growth) had been weeded and staked two weeks after planting. All farmers in Kapchorwa weeded their *N2A* and *own* plots an equal number of times.

Figure 15 – Two sloping climbing bean plots in Kanungu. The plot on the right was staked very late and was not weeded, and the plot on the left was staked two weeks after planting and weeded. Both plots were N2A *plots from different farmers.*

4.4 Variety evaluation

Improved bean variety *Nabe 12C* was more appreciated by farmers than local varieties *Mubano* and *Attawa*. In Kanungu, *Nabe 12C* had higher yields than some other varieties, but also other qualities like seed size, fodder quantity and marketability were appreciated in *Nabe 12C.* Harvested *Nabe 12C* looked unusual however: the seeds had different shades of black/purple/red spots. Beans are self-pollinating and cross-pollination is highly uncommon. The plant breeders also remarked that no cross-pollination had occurred (Onyinge, 2015), so the cause of the multi-coloured seed yield is yet unknown. It may affect next season's production if farmers use saved seed.

Some factors in the farmers' evaluation were difficult to score. In the Southwest, drought tolerance of new varieties was hard to assess, because there had been no drought. Farmers were able to give scores for the local varieties based on years of experience. The marketability of *Chesoy* and

Katuna was often not known because those varieties were new and farmers had not yet tried to sell them. Some farmers complained that it was difficult to sell their beans because they sold small quantities. N2Africa could explore further facilitation in community development because large quantities of beans (combined yields) may be easier to sell than individual small harvests.

In all study areas, farmers were very interested in trying out new varieties and practices.

4.5 Challenges for N2Africa

Despite the exemplary production on N2Africa's demonstration trials, the implementation of improved practices on farmers' fields did not impact yield. As explained before, many factors influenced this, and these reveal focal points for N2Africa that may help to improve the impact of the project in the future. These points are discussed in Chapter 6.

5 Preliminary conclusions

Overall mean climbing bean yields were low: below 1 t ha^{-1}. Fertilizer use did not influence yield, except when farmers applied NPK, which improved yields. Variety *Nabe 12C* gave highest yields in Kanungu. In Kapchorwa, row planting resulted almost significantly in higher yields than random planting.

Farmers explained that heavy rains and severe damage by animals (largely) overturned the effects of management and planting practices. Low soil fertility was also mentioned by farmers as an explanation for low yields.

Yields were not better on *N2A* plots compared to farmers' *own* plots. The recommended planting (spacing and staking) practices applied by the farmers were not different from local practices used on the *own* plots, except in Kanungu. The practices on the *N2A* plots were still more similar to the recommended practices.

Not all farmers that used improved planting practices on their *own* plots explained whether this was because of tradition or recommendations. It is therefore not completely clear whether local practices are similar to recommended practices, or whether farmers tried new improved planting practices on their *own* plots.

The application of (in)organic fertilizer on climbing bean fields was uncommon in Kabale and Kanungu. Intercropping beans is very common in Kapchorwa (over 80% of farmers) and less so in Kabale and Kanungu (about 30% of farmers intercropped their bean plots). Beans were mainly intercropped with bananas. Row planting was the traditional practice in Kabale, but it was a new practice (for climbing beans) in Kanungu. In Kapchorwa, about half of the farmers planted in rows.

Only very few farmers experimented with staking practices other than single staking. The benefits of tripods were not understood, and string staking was too expensive and labour intensive.

Improved bean variety *Nabe 12C* was more appreciated by farmers than local varieties *Mubano* and *Attawa*.

Farmers saw the potential of climbing bean production in N2Africa's demonstration trials, but practical and external constraints limited production on the farmers' own fields. Clear challenges were identified that need to be tackled in the future, in order to improve climbing bean yields.

6 Main constraints and proposed interventions

Pests, low soil fertility and stake scarcity were perceived as important constraints by farmers. These problems as well as suggestions to mitigate them are discussed in the next sections. Additionally, propositions are made to further improve N2Africa's research functionality.

6.1 Pests

Most climbing bean plots were considerably damaged by rats, birds and livestock, whereas insects pests did not have a large impact according to farmers. N2Africa goals cannot be reached if legumes are completely destroyed by pests. Rather than providing fertilizer, N2Africa could consider investing more labour or funds into pest control.

Problem	Suggestion
Rats	
Rats cut bean stems without eating the plants, but leaving them to perish (*Figure 16*). They thrive in smallholder mosaic landscapes where they can find various sources of food and shelter (Makundi et al., 1999). Clean, open fields are avoided because of the threat of predators. The mulch layer that is necessary for soil fertility management is highly favoured by rats.  *Figure 16 – Dead bean plants on stakes as a result of damage by rats.*	- Provide (accessibility of) reusable <u>pitfall traps</u>: small tins or buckets to be buried up to the edge, half filled with water. Rats will drown. Pitfall traps have proven to be successful in rodent control (Makundi et al. 1999). Belmain (2010) found that setting out traps daily was not too labour-intensive because farmers had to visit their plots anyway, and that traps could easily be rotated within a community. Altogether it proved an effective measure against rats, despite any costs. - Promote keeping <u>cats</u>: Only very few farmers kept some stray cats around their household, they are not common pets. Although cats are mainly effective against mice, they can also highly affect rat populations (Desoky, 2015). The option of upscaling keeping cats by farmers could be explored. - Place <u>owl nesting boxes</u>: Nest-box schemes for rodent control by owls were highly effective in Kenya, Israel and Florida (Ojwang and Oguge, 2003; Meyrom et al., 2009; Martin et al., 2009). In some African countries, the general public associates owls with witchcraft (Enriquez and Mikkola, 1997), thus preventing implementation of biocontrol by owls. Cultural views should not be overlooked when introducing an animal. - Maintain clear edges, use wide spacing and reduce mulching for clear, <u>open fields</u>: Some farmers tried maintaining cleared edges of their plots to keep rats away but they were

satisfied with this method to varying extents. After harvest, livestock grazing on the stubble could clear the fields in order not to attract rats. However, removing the residues could negatively impact soil fertility and cause erosion (Makundi et al., 1999). This tradeoff should be carefully considered before acting.

- Rodenticides if ecological methods fail. However, rodenticides are not affordable for most households (Nalwanga and Ssempebwa, 2011)

Birds

Climbing beans are slightly sweeter than bush beans, which makes them attractive to birds (Ramaekers et al., 2013). Birds pick flowers and young pods, preventing pod development (*Figure 17*). Methods to drive away birds are often effective for a short period only, because they get used to scarecrows and shimmering objects.

Figure 17 – Parts of young pods eaten by birds.

Large-scale bean production planning:
In sorghum, bird damage is controlled by simultaneous, collective planting. The abundance of sorghum spreads bird damage over a large area. All farmers are affected a bit, instead of losing the crop completely after planting individually. As long as N2Africa is demonstrating sole-cropped climbing beans, it could be recommended to farmer communities to combine bean fields and to synchronize planting so that the beans flower at roughly the same time.

Livestock

Cows, goats and chickens caused a lot of damage in bean fields by trampling plants, knocking over stakes, and eating the plants or pods.
There are generally no fences, but livestock is bound to a stick in the ground with one leg. However, I have observed many animals walking around after the stick had fallen.
Several farmers also indicated that some other people are not careful in where they let their livestock graze.

- Careful herding, binding livestock properly.
- Intercrop beans with maize or bananas. According to farmers this helps to make it clearer that the field is meant for food production and that livestock should not be left to graze there.

Aphids

Black bean aphids were very abundant in the bean fields, damaging the plants, distorting plant growth.

- Pick and destroy infested leaves.
- Detop beans:
Aphids are mainly found in top leaves, so detopping could be an effective control measure. In the Southwest, the practice of detopping is incorporated in some N2Africa trials to research the effect on yield (Onyinge, 2015).

6.2 Soil fertility

Many farmers complained about infertile soils, especially in Kabale and Kanungu. Soil fertility was highly variable in these areas (see *Figure 18*). N2Africa demonstrates and distributes fertilizers and animal manure to boost production. However, the large majority of farmers does not use fertilizers because they are too expensive for them. If they have access to fertilizers, they tend to use them for (cash) crops other than beans. Some manure was applied in some cases.

Figure 18 – Differences in soil fertility on a sloping climbing bean field in Kanungu.

Unfortunately, mineral fertilizer, animal manure and crop residues are all scarce. There are multiple other uses of crop residues that compete with its function as organic fertilizer, including use as livestock feed or fuel (Castellanos-Navarrete, 2015). Besides, farmers have to decide carefully on which crops they want to use the few available resources.

Some farmers had access to some manure because they kept livestock. However, at present this manure may not be as functional as it could be, as a result of losses during manure storage. Large livestock such as cows often graze in restricted areas on family land or common grazing areas. Manure is sometimes collected but in many cases just left to fertilize the grazing spots. Smaller livestock like goats are often kept in small, elevated stables. Manure falls through grooves in the flooring and collects below. The main reason for elevating the stables is to keep them clean (communication with farmers). Before using the manure on the fields, it may be stored below the stable for a long time.

There is a clear challenge: how to improve production when fertilizers are not available and when manure is also scarce? Even the use of crop residues as organic fertilizers competes with its functions as livestock feed or fuel.

Problem	Suggestion

Manure storage

Uncovered, stored manure can be losing many nutrients in gaseous form and dissolved in rain water. Heavy rains and soil erosion (manure piles were found on steep land) amplify nutrient leaching. Farmers may not be aware that they are losing valuable nutrients during storage of manure.

- Practices like covering manure piles could be promoted. Mixing the manure with straw, household waste, immature weeds and covering them with banana leaves may already help saving some nutrients.

Field composition

Clear nutrient gradients were visible on sloping fields, especially in the more open landscape in the Southwestern region (*Figure 19*). Hillsides show an array of soil types with different levels of fertility, constituting a catena (Keatinge et al., 1999).

Figure 19 –Soil fertility gradient on a sloping climbing bean field in Kabale.

As a result of erosion and heavy rain, soil and nutrients flow down until they are held by deeper-rooting vegetation or other ridges, leaving the steep middle part of the field highly infertile.

Some farmers planted strips of shrubs along the contours of their sloping fields, and mulching with uprooted weeds is common. However, I have barely seen other soil erosion prevention such as ridges or cover crops. Soil erosion is considered as an unwanted by-product of agriculture that is beyond the control of farmers (Keatinge et al., 1999). Besides, bio-physical, socio-economic and institutional factors influence the level of adoption of soil conservation practices for individual farmers (Fungo et al. 2011).

Perhaps the placement of the legumes promoted by N2Africa can be improved to enhance their beneficial effect? Rather than having a separate field with legumes, it may be worthwhile to plant legumes in strips along the upper side of a field with another main crop. The fixed nitrogen may benefit the crop directly below it on a sloping field if the fixed N ends up downhill anyway.

Planting climbing beans along the upper edges of different fields or in complicated intercropping designs may not be reasonable because of labour intensity, considering that farmers would have to bring stakes to areas that may be far apart. In this case, other edible legumes such as cowpeas or bush beans may be more effective. Shrubs or trees marking the edges of some fields may be replaced or complemented with leguminous trees such as *Leucaena spp.* that can be a source of green manure, fuel and fodder, while conserving the soil with deep roots that fix nitrogen.

Bean performance is best in sole cropping systems, supporting a cropping design with wide strips. However, alternate row intercropping for example may benefit the other crop. The legume could be planted in narrower or wider strips, depending on the importance of the legume and the other food or cash crop.

Legume residue

Beans are harvested when the plant is completely dried out. Some farmers harvest the complete plant and feed the residues to livestock, others only harvest the pods and leave the residues in the field.

If beans are produced for home consumption rather than for the market, it could be promoted to consume the young, green beans in their pods. The residues could be put down on the field while still green, contributing more N to the soil as compared to dry, brown residues. Fresh material contains more N than dried-out plant litter (Seneviratne, 2000).

The consumption of pods rather than grains also has nutritional benefits. Fresh faba bean pods contain eight times more vitamin A and C as compared to cooked dry beans and only slightly less protein (nutritiondata.self.com).

Some farmers already consume pods rather than dry grains, but this behaviour could be further stimulated on account of nutrition and soil fertility.

4.3 Stake availability

The availability of staking material is one of the main limiting factors in the production of climbing beans. Stakes are expensive as a result of high demand and low availability. In Kapchorwa, most farmers resorted to collecting whatever they could find. However, it has recently been prohibited to collect wood in the forest. Law offenders face fierce penalties. In the Southwest – and mainly in Kashambya – relatively many farmers had their own tree plantations (usually *Eucalyptus spp.* or *Pinus patyrus*) and therefore free access to stakes. The remaining farmers had to buy stakes or collect free, low-quality sticks in the area.

After the interview, many farmers in all areas mentioned again that stake availability was a problem. They would be interested in new staking methods that require the least amount of stakes possible. Farmers liked string staking for that reason, and also because it looks nice. However, they also indicated that sisal or other strings are too expensive and can only be used for one season. Additionally, the large, supporting poles are hard to find and the construction is labour intensive to build.

Problem	Suggestion
Stakes	
Farmers without their own tree plantation complained that stakes are very hard to find and that it is labour intensive to collect and carry the stakes for long distances. Some farmers are able to buy some low-quality staking material but in many cases purchasing stakes is considered too expensive altogether. In response to the question *'why did you choose this staking material'*, they would answer *'this is what I could afford'*. An additional problem is that using sticks as stakes competes with their potential function as firewood, which is needed on a daily basis. The scarcity of woody material results in women being forced to travel large distances to fetch it and carry a heavy burden all the way back.	Reuse <u>plastic waste</u> for strings: The best replacement for using stakes and strings would be a material that is freely available and is not much used for other purposes. I noticed a lot of plastic waste in ditches and covering the streets in the centres of parishes. In some cases it is burned, but not collected and recycled. Recently a cheap tool has been developed to easily cut plastic bottles and make long strings of variable width (*Figure 20*, plasticbottlecutter.com). A 4 mm wide plastic string can carry up to seven kilograms. Cutting bottles does not take much time so a lot of material could be provided within minutes, while reducing litter. Farmers could collect some plastic bottles on their way to a demonstration trial, someone could be cutting during the procedure and have lots of string material for interested farmers by the end of it. A risk of this method is that after production, the long, plastic strands may end up in the environment again, with the tangled strings being a hazard for animals and children. Distribution of this method should therefore be accompanied by warnings. The strings could potentially be reused again to make baskets but at least they should be collected after use.

Finding good supporting poles for the string construction would still be a challenge, but at least the expensive sisal strings or weak banana fibres can be replaced by cheap, readily available material.

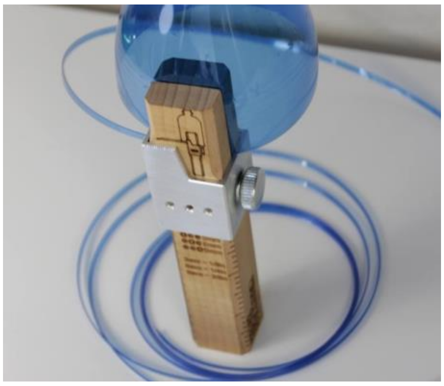


Figure 20 – Bottlecutter. Source: www.plasticbottlecutter.com

6.4 N2Africa project functionality

6.4.1 Demonstration trials

It was clear that the field liaison officers did what they could to ensure proper management of the demonstration trials by facilitating the logistics and checking regularly on the field assistants and farmers responsible for the demos. It is understandable, however, that not every demonstration trial is managed to its utmost potential, considering the scale of the project, logistical challenges, and reliance on lower-educated associates. The encountered demonstration trials revealed much variety in quality of management. In some cases, the farmers complained about specific management aspects or weaknesses were identified.

Some of the suggestions listed below are already executed in some demonstration trials, but not in others. Suggestions sometimes include extra work and/or larger demonstration trials.

Problem	Suggestion
Clarity	
For passers-by it is not clear which varieties and treatments are shown on various plots in a demo.	Add clearly visible signs stating the variety and treatment at each plot in a demo.
Staking	
Late delivery of stakes, low quality, short stakes. Plots that were assigned to tripods or string staking were not staked in some cases.	N2Africa recommends strong and long stakes, this should be visible in the demos. Based on the low availability of strings for string staking and the low appreciation of tripods, I would recommend not to put much effort into demonstrating these practices.
Sole cropping vs. intercropping	
All demos are sole-cropped cultures in open fields. However, especially in Kapchorwa, most farmers intercropped their climbing beans with bananas.	Sole-cropped climbing beans are more productive than when they are intercropped (Ruganzu, 2014). However, farmers indicated that they had no other land available than the space between the banana plants, or they remarked that they prefer a variety of crops over one on the same area. If reality is that many fields are intercropped, this should be represented in demos.
Use of herbicides, pesticides and fungicides	
Climbing beans in the demos are preventatively or curatively treated with herbicides, pesticides and fungicides although these inputs are used by only a few farmers.	The majority of farmers does not use sprays. It is good to show farmers the benefits of these inputs and more so if they can be made more accessible.

Bean diseases are big problems for farmers. In the demos, they are suppressed using sprays. Most farmers do not have those means and must rely on other methods.	However, may be more useful to focus on ecological or organic production methods because that is what farmers can apply. This could include transfer of knowledge about bean diseases (in demonstrations or with clear educative signs) and practical management approaches, or showing the differences between well weeded plots and badly weeded plots.

Farmers' practice control plots

Control plots in demos are sprayed and weeded. No plots truly represent the traditional practices of farmers.	*Farmers' practice control plots* give farmers a clear reference towards the improved technologies in the same field. These plots should receive absolutely no inputs and only one weeding intervention, considering that the majority of farmers is used to producing beans without any fertilizer and pesticides/fungicides. In the Southwestern highlands broadcasting seeds was very common, so this should be part of the demo.

Planning

Late delivery of planting and staking material delays the demos. Late distribution of packages resulted in some farmers planting the beans on inferior plots they had not reserved for beans, or saving the seeds until next season.	This is not an unknown problem and it is understandable that delays occur considering the logistics that come along with a project of this size. It is simply necessary to plan early. The demonstration trial sites should be chosen earlier and the packages should be distributed earlier.

Instruction leaflet

Only 40% of the farmers received the instruction leaflet. Most farmers are illiterate and cannot read the instructions.	- Distribute the leaflets along with the package. - Translate the leaflet into the local language. If people know how to read, their own language may be more understandable. - Based on farmers' handwritings, I am under the impression that using capital letters is simplest. - An edited instruction leaflet with less text is proposed as an alternative: see *Figure 21* and *22.*

Package delivery after the demo

Some farmers received their package with beans and fertilizers later, after the general distribution. They often received them with only few instruction, which is not useful.	If farmers receive their package later, make sure they understand the instructions that are essentially part of the package.

INSTRUCTIONS FROM *N2AFRICA*

YOU RECEIVED A PACKAGE WITH SEED OF AN IMPROVED VARIETY + FERTILIZER.
YOU CAN FOLLOW THE INSTRUCTIONS BELOW OR DO WHAT YOU THINK IS BEST.

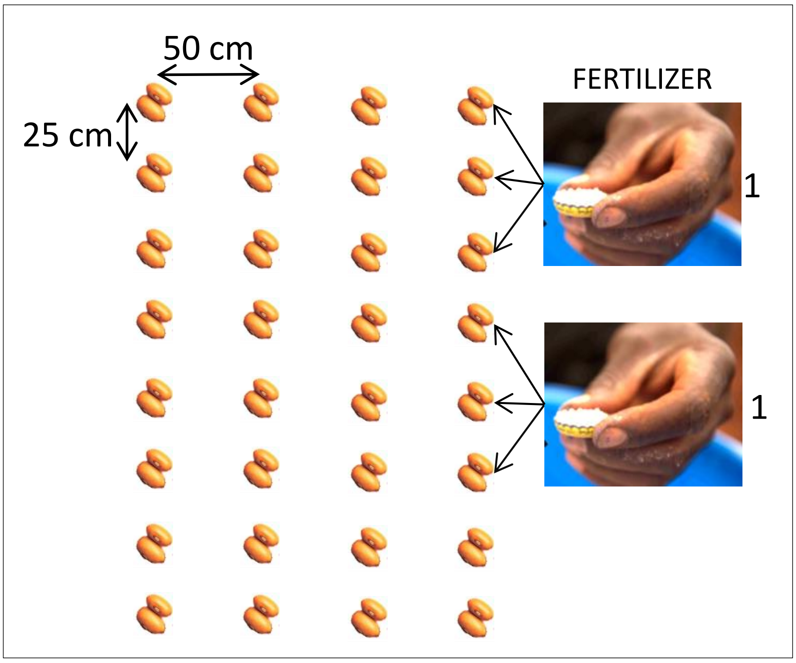
PLANTING

BETWEEN ROWS: 50 CM

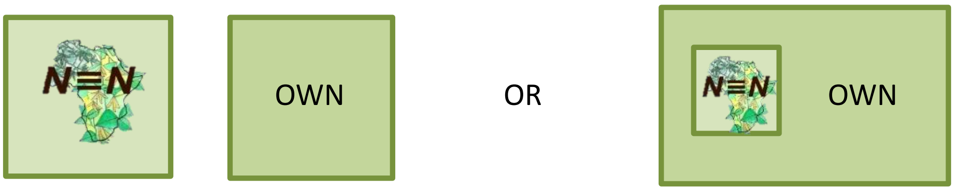
BETWEEN PLANTS: 25 CM

2 SEEDS PER HOLE

FERTILIZER FROM PACKAGE:
1 BOTTLECAP PER 3 HOLES



PLANT THE PACKAGE AND YOUR OWN LEGUME CLOSE TO EACH OTHER:



STAKING

AFTER 2 WEEKS
4 PLANTS PER STAKE
LONG STAKES

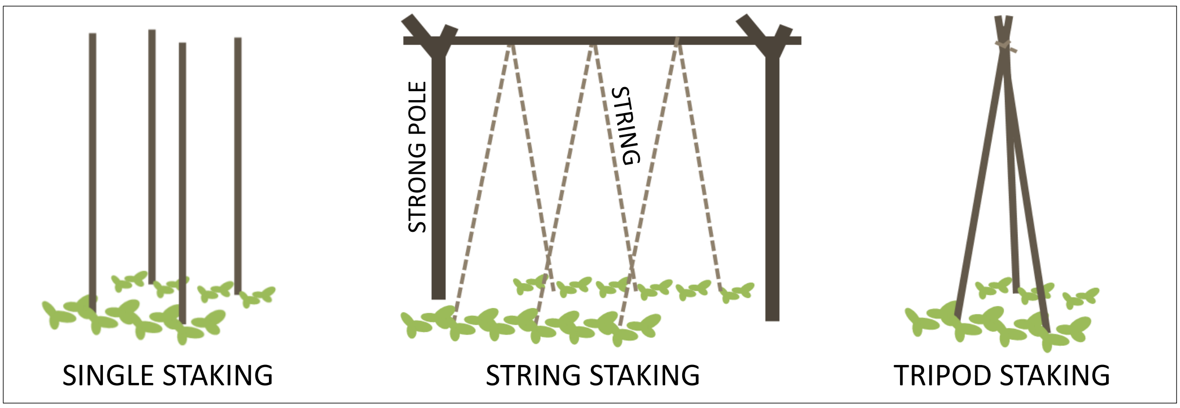


Figure 21 – Edited instruction leaflet; front page.

HARVESTING

HARVEST THE PLOT WITH THE PACKAGE AND YOUR OWN PLOT SEPARATELY. **DO NOT MIX.**

OWN

N2AFRICA LEGUME	
AMOUNT OF GRAINS HARVESTED	
AMOUNT OF SEED PLANTED	

OWN LEGUME	
AMOUNT OF GRAINS HARVESTED	
AMOUNT OF SEED PLANTED	

PRACTICE	DATE
PLANTING	
FERTILIZER APPLICATION	
MANURE APPLICATION	
STAKING	
WEEDING 	
PESTICIDE APPLICATION 	
HERBICIDE APPLICATION	
HARVESTING	

Figure 22 – Edited instruction leaflet; back page.

6.4.2 Data collection

A tablet was used for data collection, which was very convenient in comparison to carrying sheets of paper around and later digitalizing data manually. The only problem of using a tablet is that it requires energy. A power bank was a necessity especially in the Southwest.

I also want to stress the importance of explaining that the results of this research will be communicated with the farmers so that they can potentially improve on their bean production. Some farmers assumed that European researchers just leave with their data to publish it and be done with it, while the farmers do not benefit.

Problem	Suggestion
Questions not applicable	
Sometimes questions could not be answered, but this could not be indicated. E.g. drought tolerance of a variety had to be indicted, but there had not been drought. Answer boxes of open questions could be left empty. However, for other questions, an option had to be clicked. If this happened accidentally, it could not be undone in order to leave the question open.	Include “don’t know” or “not applicable” options.
Respondent responsible for planting	
It happened that it became clear later in the survey that the respondent who considered himself responsible for the field (the one who received the package), was not the one who planted the plots. In many cases it was the male head of the household who visited the demo, but the farmer’s wife who planted and participated in the survey.	- Always ask whether the respondent was really the one who planted the package and the own plot. The farmer who planted should be interviewed. - Include question: “Who visited the demonstration trial?” >> respondent / other / did not visit. - Enter sex of the farmer who visited the demo and the farmer who planted.
Education level respondent	
When asked about the highest level of education, many farmers did not finish primary school and they answer with P1, P4, P6, etc.	- Because there is a difference between P1 and P6 or between P5 and not going to primary school at all, inclusion of a response box to enter the level of education could be useful. - Add option “No education”.
Bean evaluation	
In the survey, a general score for the planted varieties was requested, followed by a detailed evaluation of bean / production characteristics.	The detailed evaluation seemed a lot more useful. Respondents found it difficult to give a general score that covered their appreciation of

	the variety *and* the practices, so farmers based their score on other things like only the colour of the beans. I would advise to take the general score out of the survey, and keep the detailed assessment.

Scoring appreciation

For the evaluation of many characteristics of the planted varieties, farmers were requested to give a score of 1 to 5 to grade their appreciation of the characteristic. This was very complicated for many farmers.	- Bring a visual, tangible scale with clear (African) smiling/disappointed faces or thumbs up/down, on which farmers can point out their appreciation. - An alternative could be to ask whether the variety from the package performed better, similar or worse compared to the own variety.

Survey length

Farmers complained about the length of the survey. They got annoyed during (seemingly repetitive) questions about production in previous seasons.	Carefully test the survey. Questions that were intended as fast scoring questions (variety evaluation), took very long in practice.

Define varieties

During the second visit, harvest data were collected. Sometimes it became clear that farmers had been mistaken about the variety they planted during the first visit.	Include questions in part 2 of the survey: “Which variety did you receive in the package?” “Which variety was planted on your *own* plot?”

Planting practice

When farmers did not plant in rows, they either planted seeds in random holes or they broadcasted. When a plot was broadcasted I entered this as 1 seed ‘per hole’ and average spacing (broadcasted spacing was very variable). Other surveyors might do it differently.	Add text box to enter whether the plot was planted in randomly distributed holes or broadcasted, if the respondent indicated that the plot was not planted in rows.

Measuring in part of plot

Some farmers had very large *own* plots. It would not be reasonable to ask them not to consume or sell part of this before I returned to collect harvest data. In those cases, only a definable part of the plot was used for measurements and the farmer kept the yield of that part separate.	Add question: “Was only a part of the plot taken for measurements?” >> Yes/no. This helps to not forget about this intervention. During harvest data collection, the surveyor should check whether the farmer indeed kept this part separate.

Measuring plot sizes

Plot sizes were very variable in size and shape. This season I tested the *Agroid GPS Area Meter App* but I quickly stopped using it because it seemed less convenient and even less reliable than using a tape measure.
Using the Agroid App includes walking along the sides of a plot while tapping on the tablet. During each tap, GPS coordinates are collected. Based on these coordinates, the *App* calculates the plot size. Especially on sloping fields with soil cover, having to hold the tablet with both hands while tapping was inconvenient and unsteady.

- For small and large plots, measuring tape was a faster method. For small plots, measuring tape seemed more accurate than the *Agroid App*.
- When plots are not rectangular, the *Agroid App* could be more reliable. In practice, I still used measuring tape on transects through average parts of the plot, to reduce walking distance in order to avoid any damage to crops. The other end of the measuring tape was always held by the farmer of the translator, and together we would decide how to measure plot size most accurately.

Appreciation

In season 2014B, farmers in Kapchorwa received a bar of soap after collection of the harvest data. During this season, 2015B, farmers had heard about this and requested soap as well. Because it would otherwise seem unfair, I also gave farmers a bar of soap after the second interview.
In the Southwest, farmers never received a gift after a survey, so also in 2015B no gifts were distributed.

Giving gifts one time has consequences for all future data collection occasions. Farmers can get annoyed or feel treated unfairly if they do not receive a gift knowing that others previously received some tangible appreciation.
Starting a trend like this should be discussed well with the field liaison officers and central N2Africa staff.

7. Concluding remarks

Measured and expected climbing bean yields were low, mainly as a result of very heavy rains during the El Niño episode of season 2015B, and a lot of damage by pest animals. Yields on plots where NPK was applied were best, and the provided TSP did not improve yields. *Nabe 12C* was the highest yielding and most appreciated variety. The implemented planting practices and methods of row and sole cropping did not improve climbing bean yields. Any effects of these management practices may be more pronounced in years with more stable weather or when pest animals are restricted. Scarcity of staking material and low soil fertility were other constraints of climbing bean production.

Beans are very likely to remain a prominent part of the Ugandan diet, so efforts put into optimizing their production are never wasted. Opportunities arise in better management of pest animals, alternative staking material, and better nutrient management. Not all of the suggested interventions imply higher labour intensity for farmers.

N2Africa could improve on earlier planning and optimize their demonstration trials, but farmers already expressed their gratitude and appreciation about the research that is being done. They welcome the improved technologies and are eager to try them out.

References

African Development Fund (AFD) (2014). *Road sector support project V – country: Uganda.* Appraisal report, May 2014.

Alinyo, F., & Leahy, T. (2012). Designing food security projects: Kapchorwa and Bukwo, Uganda. *Development in Practice*, *22*(3), 334-346.

Bamutaze, Y., Tenywa, M. M., Majaliwa, M. J. G., Vanacker, V., Bagoora, F., Magunda, M., Obando, J. & Wasige, J. E. (2010). Infiltration characteristics of volcanic sloping soils on Mt. Elgon, Eastern Uganda. *Catena*, *80*(2), 122-130.

Briggs and Roberts (2010). *Bradt travel guide – Uganda*, Bradt travel guides Ltd, UK.

Castellanos-Navarrete, A., Tittonell, P., Rufino, M. C., & Giller, K. E. (2015). Feeding, crop residue and manure management for integrated soil fertility management–a case study from Kenya. *Agricultural Systems*, *134*, 24-35.

Checa, O., Ceballos, H., & Blair, M. W. (2006). Generation means analysis of climbing ability in common bean (*Phaseolus vulgaris* L.). *Journal of Heredity*, *97*(5), 456-465.

Desoky, A. E. A. S. S. (2015). Application of different methods for rodent control in Upper Egypt. *Researcher* 7(9): 90-93.

Ebanyat, P., de Ridder, N., De Jager, A., Delve, R. J., Bekunda, M. A., & Giller, K. E. (2010). Drivers of land use change and household determinants of sustainability in smallholder farming systems of Eastern Uganda. *Population and Environment*, *31*(6), 474-506.

Enriquez, P. A., & Mikkola, H. (1997). Comparative study of general public owl knowledge in Costa Rica, Central America and Malawi, Africa. In Duncan J.R., Johnson, D.H. & Nicholls, T.H. (Eds) *Biology and conservation of owls of the Northern Hemisphere*, p. 160-166.

Esmaeilzadeh, S. and Aminpanah, H. (2015). Effects of planting date and spatial arrangement on common bean *Phaseolus vulgaris L.*) yield under weed-free and weedy conditions. *Planta Daninha*, *33*(3), 425-432.

FAO, 2006. Country Pasture/Forage Resource Profiles: Uganda. Mwebaze, S.M.N. (Ed.).

Fungo, B., Tenywa, M., Majaliwa, J., Kuule, M., & Kamugisha, R. (2011). Use of soil conservation practices in the Southwestern highlands of Uganda. *Journal of Soil Science and Environmental Management*, *2*(9), 250-259.

Gabiri, G. (2013). Climbing and bush beans' cultivation effects on runoff, soil properties and soil and nutrient losses in Bufundi sub catchment, Uganda. BSc thesis at Kenyatta University, Nairobi, Kenya.

Gabiri, G., Obando, J. A., Tenywa, M. M., Majaliwa, J. G., Kizza, C. L., Zizinga, A., & Buruchara, R. (2015) Soil and nutrient losses under cultivated bush and climbing beans on terraced humid highland slopes of Southwestern Uganda. *Journal of Scientific Research and Reports, 8*(3), 1-16.

Gidoi, R. (2013). *Effect of access to market of agricultural commodities on soil and water conservation investment in Sebei Sub Region, Eastern Uganda* (Doctoral dissertation, Makerere University).

Giller, K. E. (2001). *Nitrogen Fixation in Tropical Cropping Systems*. Wallingford (UK), CABI.

Gollin, D., & Rogerson, R. (2010). *Agriculture, roads, and economic development in Uganda* (No. w15863). National Bureau of Economic Research.

Haggblade, S., & Dewina, R. (2010, January). Staple food prices in Uganda. In: *Prepared for the Comesa policy seminar on "Variation in staple food prices: causes, consequence, and policy options," Maputo, Mozambique* (pp. 25-26).

Kanabahita, C. (2001). Forestry outlook studies in Africa (FOSA) Uganda. *Forestry Department, Ministry of Water, Lands & Environment: Kampala, Uganda*.

Hardarson, G., Zapata, F., & Danso, S. K. A. (1984). Effect of plant genotype and nitrogen fertilizer on symbiotic nitrogen fixation by soybean cultivars. *Plant and Soil*, *82*(3), 397-405.

Katungi, E., Larochelle, C., Mugaboo, J., & Buruchara, R. (2016). Estimating the impact of climbing bean adoption on bean productivity in Rwanda: Endogenous Switching Regression. In *2016 AAAE Fifth International Conference, September 23-26, 2016, Addis Ababa, Ethiopia* (No. 246456). African Association of Agricultural Economists (AAAE).

Keatinge, J. D. H., Qi, A., Wheeler, T. R., Musitwa, F., Franks, N. A. P., Kuribuza, D., Ellis, R. H. & Summerfield, R. J. (1999). Potential annual-sown legumes for low-input systems in the East African Highlands of southwestern Uganda. *Mountain Research and Development*, 345-353.

Makundi, R.H., Oguge, N.O. & Mwanjabe PS. (1999). Rodent pest management in East Africa - an ecological approach. In: Singleton, G.R., Hinds, L.A., Leirs, H. & Zhang, Z. (Eds*). Ecologically-based management of rodent pests*. Canberra, Australia: ACIAR. p 460-76.

Martin, J. M., Raid, R. N., & Branch, L. C. (2009). Barn owl (Tyto alba).*University of Florida, IFAS Extension*, *185*(1), 1-3.

Mauyo, L. W., Chianu, J. N., Nassiuma, B. K., & Musebe, R. O. (2010). Cross-border bean market performance in Western Kenya and Eastern Uganda. *Journal of Service Science and Management*, *3*(04), 501.

Mauyo, L. W., Okalebo, J. R., Kirkby, R. A., Buruchara, R., Ugen, M., & Musebe, R. O. (2007). Legal and institutional constraints to Kenya-Uganda cross-border bean marketing. *African Journal of Agricultural Research*, *2*(11), 578-582.

Meyrom, K., Motro, Y., Leshem, Y., Aviel, S., Izhaki, I., Argyle, F., & Charter, M. (2009). Nest-box use by the Barn Owl Tyto alba in a biological pest control program in the Beit She'an valley, Israel. *Ardea*, *97*(4), 463-467.

Mukuve, F. M., & Fenner, R. A. (2015). The influence of water, land, energy and soil-nutrient resource interactions on the food system in Uganda. *Food Policy*, *51*, 24-37.

Nalwanga, E., & Ssempebwa, J. C. (2011). Knowledge and practices of in-home pesticide use: a community survey in Uganda. *Journal of Environmental and Public Health*, *2011*.

National Environment Management Authority (NEMA) (2004). *Kapchorwa district state of the environment report 2004.*

National Environment Management Authority (NEMA) (2001). *State of the environment report for Uganda 2000/2001.*

National Environment Management Authority (NEMA) (2004). *Kapchorwa district state of the environment report 2004.*

Nkonya, E. (2002). Soil conservation practices and non-agricultural land use in the south western highlands of Uganda. *The International Food Policy Research Institute (IFPRI)*, *2033*.

Ojwang, D. O., & Oguge, N. O. (2003). Testing a biological control program for rodent management in a maize cropping system in Kenya. *Aciar Monograph Series*, 96, 251-253.

Ramaekers, L., Micheni, A., Mbogo, P., Vanderleyden, J., & Maertens, M. (2013). Adoption of climbing beans in the central highlands of Kenya: An empirical analysis of farmers' adoption decisions. *African Journal of Agricultural Research*, *8*(1), 1-19.

Rockström, J., & Falkenmark, M. (2000). Semiarid crop production from a hydrological perspective: gap between potential and actual yields. *Critical Reviews in Plant Sciences*, *19*(4), 319-346.

Ruganzu, V. (2014). *ASARECA's climbing bean project has improved livelihoods in Rwanda, Burundi and eastern DR Congo*. Published on ASARECA (http://asareca.org/~asareca)

Sassen, M., Sheil, D., Giller, K. E., & ter Braak, C. J. (2013). Complex contexts and dynamic drivers: understanding four decades of forest loss and recovery in an East African protected area. *Biological Conservation*, *159*, 257-268.

Seneviratne, G. (2000). Litter quality and nitrogen release in tropical agriculture: a synthesis. *Biology and Fertility of Soils*, 31(1), 60-64.

Sperling, L. & Muyazena, S. (1995). Intensifying production among sm*allholder* farmers: the impact of improved climbing beans in Rwanda. *African Crop Science Journal, 3*(1), 117-125.

Swaibu, M., Kizza, C.L., Komayombi, B. (2015). *Are Ugandan farmers using the right quality inorganic fertilizers?* Policy brief no. 56 of the Economic Policy Research Centre.

Uganda Bureau of Statistics (UBOS) (2010). *Summary report on Uganda census of agriculture 2008/2009.* December 2010.

Uganda Bureau of Statistics (UBOS) (2012a). *Kanungu district local government statistical abstract.* June 2012.

Uganda Bureau of Statistics (UBOS) (2012b). *Kabale district local government statistical abstract.* June 2012.

Uganda Bureau of Statistics (UBOS) (2012c). *Uganda demographic and healthy survey 2011.* August 2012.

Ugandan Bureau of Statistics (UBOS) (2014). *National population and housing census 2014; provisional results*. November 2014, revised edition.

Uganda National Meteorological Authority (UNMA) (2015). *The current status of El Niño 2015 and outlook.* Issue: Dec 1st 2015.

Woelcke, J. (2006). Technological and policy options for sustainable agricultural intensification in eastern Uganda. *Agricultural Economics*, *34*(2), 129-139.

Woomer, P. (2011). *Inoculation and staking systems of climbing bean in Kenya.* Published on October 31st, 2011 on *N2Africa* (https://n2africa.org).

Wortmann, C. S. (1998). *Atlas of common bean (Phaseolus vulgaris L.) production in Africa* (No. 297). CIAT.

Websites

FAO/GIEWS, 2015 - http://www.fao.org/giews/countrybrief/country.jsp?code=UGA, accessed on February 29th, 2016).

World Population Review - http://worldpopulationreview.com/countries/uganda-population/ (accessed November 2016).

climate-data.org - http://nl.climate-data.org/country/160/ (accessed March 2016)

citypopulation.de - http://www.citypopulation.de/php/uganda-admin.php (accessed March 2016)

nutritiondata.self.com - http://nutritiondata.self.com/facts/legumes-and-legume-products/4322/2

www.plasticbottlecutter.com

Persons

Byamugisha, Innocent. N2Africa extension worker in Mpungu subcounty, Kanungu district.

Onyinge, Justine. N2Africa field liaison officer in Southwestern Uganda.

Ssekamwa, John. N2Africa field liaison officer in Eastern Uganda.

Appendix

1 Survey

The text below was visible in a form on the tablet used for surveying. I formulated the questions in a way that was appropriate for conversation, and this was translated in the local language for the farmer.

1.1 Survey part 1 – mid-season

General information and household characteristics. You may conduct this part of the survey at the farmers' homestead.

Name of the person filling the form
Date when form filled
Country
District
Sub-county and parish
Name of the farmer responsible for the N2Africa field
Sex of farmer
Name of partner of farmer
Phone number of farmer or contact person
Did the farmer plant the N2Africa legume?
Did the farmer receive an N2Africa package in previous season(s)?
Did farmer fill the Field Book in previous season(s)?
Did the farmer visit the demonstration trial?
Farm ID

Household characteristics
Is the farmer head of the household?
If no, the head of the household is
Age of the head of the household

How many people form part of the household?
Please specify how many males and females of the different age groups live within the household.
0-16 years No. of females
0-16 years No. of males
17-35 years No. of females
17-35 years No. of males
36-60 years No. of females
36-60 years No. of males
Over 60 years No. of females
Over 60 years No. of males

Education
Indicate the highest level of schooling for the:
Household head
If other please specify
Person with the highest education in household
If other please specify

Land
Area:
Livestock
Indicate the number of livestock owned for:
Cattle
Sheep/goats
Pigs
Poultry
Donkey
Other

Labour
Does your household hire labour from outside the household to work in your fields?

Importance of agriculture
Indicate what best describes your household's situation in terms of production orientation:
Indicate what best describes the share of income that comes from the farm
Tick the most important sources of income for your household (Multiple answers possible)
Cropping
Livestock
Casual labour on-farm (work on other people's fields)
Trade/business
Salaried Job
Pension
Remittances
Casual labour off-farm
If other please specify
Rank of sources of income

Do you experience periods in which members of your household eat less because of food shortages?
Indicate the months when members of your household eat less due to food shortage
Please estimate the household's wealth category (poor / intermediate / wealthy

The N2Africa package
Legume species
Legume variety
Mineral fertilizer type
Other input/practice?
Did farmer receive an N2Africa instruction leaflet?

Was legume species climbing bean new?
Was legume variety new?
Was the use of fertilizer new in species}?
Was input/practice new in species?
What was the reason for choosing this package?

Planting of package and own legume
Did the farmer plant his/her own climbing beans?
Did the farmer plant a control plot next to the N2Africa plot?
Did the farmer use all seed from the N2Africa package?
Did the farmer use all inputs from the N2Africa package?
Is the own climbing bean planted in the same field as the N2Africa climbing bean?
Are the N2Africa plot and the own climbing bean plot clearly distinguishable in the field?

Which variety did the farmer plant on his own plot?
If the farmer didn't use all seed or inputs, what was done with the seed/ inputs?

N2Africa plot
Intercropping
Row planting
Which staking method did the farmer use?
Which staking material did the farmer use?
Other practices
Specify other staking method
Reason for (not) intercropping in the N2Africa plot
Reason for (not) row planting in the N2Africa plot
What was the reason for using inputs in the N2Africa plot?
Reason(s) for applying other inputs in the N2Africa plot

Own plot
Intercropping
Row planting
Which staking method did the farmer use?
Which staking material did the farmer use?
Other practices:
Specify other staking method:
Reason for (not) intercropping in the own plot
Reason for (not) row planting in the own plot
What was the reason for using inputs in the own plot?
Reason(s) for applying other inputs in the own plot

Control plot
Which staking method did the farmer use in the control plot?
Which staking material did the farmer use in the control plot?
Other practices control plot:
Specify other staking method control plot:

With which crops did the farmer intercrop in the N2Africa plot and in his own plot?
Has the farmer ever seen or tried a different staking method than the one he/she applied now?
Which method?
What does the farmer think of this other method compared with the one he/she is currently using?

Field characteristics
GPS coordinates of the N2Africa plot
GPS coordinates (North/South)
GPS coordinates (East/West)
GPS coordinates (Altitude)

Field properties of the N2Africa plot
The N2Africa plot is planted on a field that lies on:
Slope of the field (flat, moderate , steep)
In general, the fertility of the N2Africa field is (poor, moderate, good)
Compared to most other fields on the farm the soil fertility of the N2Africa field is
The drainage of the field is (poor, moderate, good)
Use the soil probe to measure the depth of the soil (in cm):
Depth at point 1, 2 and 3
Please indicate the plant/row spacing and area for the N2Africa plot:

row spacing (cm)
plant spacing (cm)
number of plants per hole
Width of plot in meters:
Length of plot in meters:
Area of plot:
Unit of plot area:
Specify unit if other:
Please count the number of stakes on an area of 2x2 m:
Number of stakes on 2x2 m
Please count the number of plants per stake on 5 random stakes:
Number of plants stake 1
Number of plants stake 2
Number of plants stake 3
Number of plants stake 4
Number of plants stake 5
Please measure the length of 5 random stakes:
Length stake 1 (cm)
Length stake 2 (cm)
Length stake 3 (cm)
Length stake 4 (cm)
Length stake 5 (cm)

Please indicate the plant/row spacing and area for the farmer's own plot:
row spacing (cm)
plant spacing (cm)
number of plants per hole
Width of plot in meters:
Length of plot in meters:
Area of plot:
Unit of plot area:
Specify unit if other:
Please count the number of stakes on an area of 2x2 m:
Number of stakes on 2x2 m
Please count the number of plants per stake on 5 random stakes:
Number of plants stake 1
Number of plants stake 2
Number of plants stake 3
Number of plants stake 4
Number of plants stake 5
Please measure the length of 5 random stakes:
Length stake 1 (cm)
Length stake 2 (cm)
Length stake 3 (cm)
Length stake 4 (cm)
Length stake 5 (cm)

Please indicate the plant/row spacing and area for the control plot:
row spacing (cm)
plant spacing (cm)
number of plants per hole
Width of plot in meters
Length of plot in meters

Area of plot in square meters

Reason for choosing this plant spacing and number of plants per hole for N2Africa plot, Own plot
Reason for choosing this number of plants per stake for N2Africa plot, Own plot
Does the farmer ever select stakes based on their length?
Why (not)?
How would you evaluate the availability of trees for staking in this area?

Please indicate the percentage of plants that have survived after planting (mid-season) for N2Africa plot, Own plot, Control plot

Field history

Field where N2Africa plot is planted:
1 season ago:
Most important crop grown
Other crops grown
Type(s) of mineral fertilizer used
Type(s) of organic inputs used
Inoculants used
Area harvested
Unit of area:
Amount harvested
Unit of harvested amount:

Field where N2Africa plot is planted:
2 seasons ago:
Most important crop grown
Other crops grown
Type(s) of mineral fertilizer used
Type(s) of organic inputs used
Inoculants used
Area harvested
Unit of area
Amount harvested
Unit of harvested amount

Please take a pictures from the N2Africa plot and the farmer's own plot
image N2Africa plot
image own plot
image control plot

Please explain the farmer how to harvest. The farmer should harvest the N2Africa plot and the Own legume plot separately (as well as the control plot, if applicable). It is important that the farmer harvests the whole plots. The harvest should be stored in two separate bags/ bowls/ etc. with clear labels. This allows you to measure the exact weight of the two harvests when you come back to complete the Field Book. Stress the importance of not mixing harvest from the two plots and not consuming or selling it before it has been measured!

1.2 Survey part 2 – after harvest

Management of the trial
inputs N2Africa plot
inputs own plot
inputs control plot

Specify type(s) of fertilizer used on the N2africa plot
Specify type(s) of fertilizer used on own plot
Specify type(s) of fertilizer used on the control plot

Specify other inputs used on the N2africa plot
Specify other inputs used on the own plot
Specify other inputs used on the control plot

Management practices
practices N2Africa plot
practices own plot
practices control plot

Specify other practices used on the N2africa plot
Specify other practices used on the own plot
Specify other practices used on the control plot

Cropping calendar of N2Africa plot (fill in date)
planting
1st weeding
2nd weeding
3rd weeding
staking
herbicide application
insecticide application
harvest

Cropping calendar of own plot (fill in date)
planting
1st weeding
2nd weeding
3rd weeding
staking
herbicide application
insecticide application
harvest

Cropping calendar of Control plot (fill in date)
planting

1st weeding
2nd weeding
3rd weeding
staking
herbicide application
insecticide application
harvest

Problems in the field (enter severity)
Drought
Water logging
Storm/hail
Frost
Pests
Weeds
Disease
Other

Type of pest
Type of disease
Type of weeds

Household characteristics - Cropping
How many fields did your household crop last season?

Please complete the table for the three most important fields cropped in the previous season. Please pay attention to units:

Field 1:
Size of the field
Unit of field size
Walking distance from homestead
Fertility of the field
Most important crop in this field
Variety of most important crop in this field
Seed source
Other crops in this field
Type of mineral fertilizer applied
How much mineral fertilizer applied?
Specify unit of fertilizer
Manure, compost or crop residues applied?
Insecticide applied?
Herbicides applied?
Area harvested
Unit of area
Amount harvested

Unit of harvested amount
Specify other
Proportion of harvest sold
What was done with the crop residue?

Field 2:
Size of the field
Unit of field size
Walking distance from homestead
Fertility of the field
Most important crop in this field
Variety of most important crop in this field
Seed source
Other crops in this field
Type of mineral fertilizer applied
How much mineral fertilizer applied?
Specify unit of fertilizer
Manure, compost or crop residues applied?
Insecticide applied?
Herbicides applied?
Area harvested
Unit of area
Amount harvested
Unit of harvested amount
Specify other
Proportion of harvest sold
What was done with the crop residue?

Field 3:
Size of the field
Unit of field size
Walking distance from homestead
Fertility of the field
Most important crop in this field
Variety of most important crop in this field
Seed source
Other crops in this field
Type of mineral fertilizer applied
How much mineral fertilizer applied?
Specify unit of fertilizer
Manure, compost or crop residues applied?
Insecticide applied?
Herbicides applied?
Area harvested
Unit of area
Amount harvested

Unit of harvested amount
Specify other
Proportion of harvest sold
What was done with the crop residue?

If legumes are produced in another field that was not mentioned before:
Most important legume planted
Most important legume planted
Variety of legume in this field
Seed source
Size of the field
Unit of field size
Walking distance from homestead
Fertility of the field
Other crops in this field
Type of mineral fertilizer applied
How much mineral fertilizer applied?
Specify unit of fertilizer
Manure, compost or crop residues applied?
Insecticide applied?
Herbicides applied?
Area of legume harvested
Unit of area:
Amount of legume harvested
Unit of harvested amount:
Specify other:
Proportion of harvest of legume sold
What was done with the legume residue?

What are common reasons for you not obtaining a good harvest in any crop?
What are common reasons for you not obtaining a good harvest specifically for legumes?

Describe the other reason for not obtaining a good harvest in any crop
Describe the other reason for not obtaining a good harvest in legumes

Harvest measurement
Did the farmer keep the yields of the different plots (N2Africa, own, control) separate?
Did the farmer already consume or sell part of the harvest?
of the N2Africa plot
of the own plot
of the control plot
Please measure the harvest of the different plots and record the weights with a precision of 10g (two decimals on a digital scale). In case of intercropping, record the legume yield only.

For the N2Africa plot
Amount of seed planted (kg)

Weight of harvested grain (kg) in case of shelled grain
Weight of harvested pods (kg) in case of unshelled grain
Amount consumed prior to harvest measurement (in kg)

For the Own plot
Amount of seed planted (kg)
Weight of harvested grain (kg) in case of shelled grain
Weight of harvested pods (kg) in case of unshelled grain
Amount consumed prior to harvest measurement (in kg)

For the Control plot
Amount of seed planted (kg)
Weight of harvested grain (kg) in case of shelled grain
Weight of harvested pods (kg) in case of unshelled grain
Amount consumed prior to harvest measurement (in kg)

How does the farmer explain the yields?
Comments from the researcher/technician
Farmer assessment of the adaptation trial
How satisfied were you, overall, with the N2Africa climbing bean package?
Please explain why you give this score
How satisfied were you, overall, with your own climbing bean plot?
Please explain why you give this score

Detailed farmer assessment
For the N2Africa package:
Grain Size
Maturity date
Resistance to diseases
Resistance to Striga and other weeds
Insect tolerance
Tolerance to other pests
Drought tolerance
Grain yield
Fodder yield
Marketability
Cost of inputs
Cost of labour
Availability of inputs
Staking method
Other criteria that you think are important

For the Own legume:
Grain Size
Maturity date
Resistance to diseases

Resistance to Striga and other weeds
Insect tolerance
Tolerance to other pests
Drought tolerance
Grain yield
Fodder yield
Marketability
Cost of inputs
Cost of labour
Availability of inputs
Staking method
Other criteria that you think are important

Are there any elements (e.g. varieties, inputs, practices) of the trial you would like to use yourself next season? If yes, please describe them:
Is there anything from the trial that you would like to improve? If yes, please describe what:

Did you also visit the demonstration trial in your parish in this season or in a previous season?

What did you find most interesting from the demonstration trial?
Did you apply anything from the demonstration trial on your own field, other than the inputs/ practices mentioned before? Please specify:
What was the reason for applying this input/ practice?
What do you think of this input/ practice?
Was there something from the demonstration trial that you did not want to, or could not apply on your own field? Please specify:
What is the reason for not applying this input/ practice?
Is there anything else that you learned from visiting the demonstration trial? Please specify:

Do you have any other comments or suggestions?

2 Bean production practices

The results discussed in the report are based on data from farmers that completed part 1 (Appendix 1.1) and part 2 (Appendix 1.2) of the survey, and where yield data were collected. This section of the Appendix contains figures and tables presenting data from all farmers: also those where no yield data were collected because they were not found back or because their *N2A* and *own* plots were not comparable (e.g. because of very different planting dates or different locations).

2.1 Intercropping

Table 1. Proportion of plots intercropped. This table includes all farmers (also those with incomparable N2A *and* own *plots and were therefore not visited a second time for yield measurements).*

District	Proportion of plots intercropped			
	N2A	*N*	*Own plot*	*N*
Kapchorwa	76 %	51	84%	39
Kabale	28 %	25	40%	20
Kanungu	50%	34	42%	33

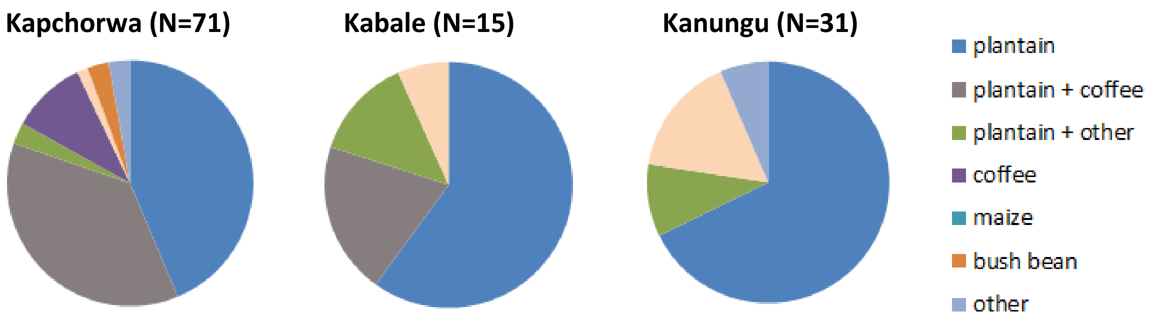


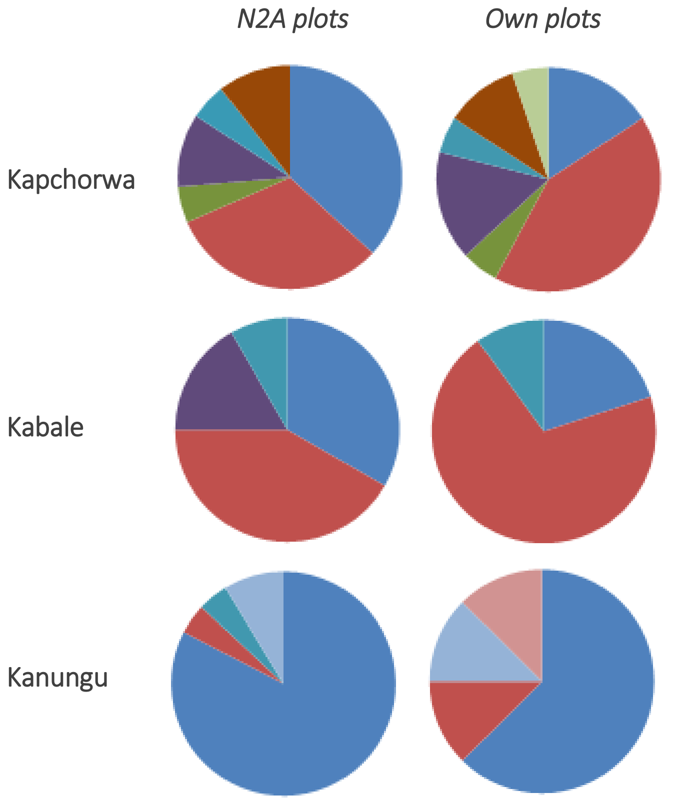
*Figure 1. Relative occurrence of crops that were intercropped with climbing beans (*N2A *plus* own *plots). This figure includes all farmers (also those where no yield data were collected).*

2.2 Row planting

Table 2. Proportion of plots planted in rows. This table includes all farmers (also those with incomparable N2A *and* own *plots and were therefore not visited a second time for yield measurements).*

District	Proportion of plots planted in rows			
	N2A	*N*	*Own plot*	*N*
Kapchorwa	59 %	51	49%	39
Kabale	100 %	25	90%	20
Kanungu	97%	34	24 %	33

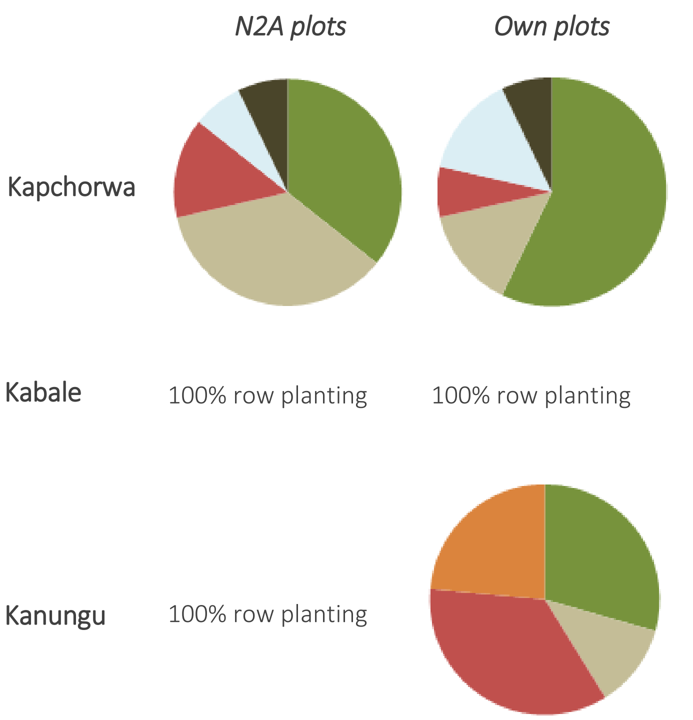
Reasons for row planting



Number of farmers planting in rows		
	N2A	*Own*
Kapchorwa	17	17
Kabale	10	10
Kanungu	21	7

Figure 2. Reasons for planting in rows on the own *and* N2A *plots, and the relative number of times they were mentioned by farmers.*

Reasons not to plant in rows



Number of farmers not planting in rows		
	N2A	*Own*
Kapchorwa	14	14
Kabale	0	0
Kanungu	0	14

Figure 3. Reasons not to plant in rows on the own *and* N2A *plots, and the relative number of times they were mentioned by farmers.*

2.3 Staking methods

Table 3. Proportion of farmers using particular staking methods on their N2A *and* own *plots. This table is based on data only from farmers where the yield was measured.*

	Kapchorwa		Kabale		Kanungu	
Plot type	*N2A (N=31)*	*own (N=31)*	*N2A (N=10)*	*own(N=10)*	*N2A (N=21)*	*own (N=21)*
Single staking	94	97	80	80	100	100
String staking	3	0	0	10	0	0
Tripods	3	3	0	0	0	0
No stakes	0	0	20	10	0	0

Table 4. Proportion of farmers using particular staking methods on their N2A and own plots. This table includes all farmers (also those with incomparable N2A and own plots and were therefore not visited a second time for yield measurements).

	Kapchorwa		Kabale		Kanungu	
Plot type	*N2A (N=51)*	*own (N=39)*	*N2A (N=25)*	*own(N=20)*	*N2A (N=34)*	*own (N=33)*
Single staking	96	97	88	90	100	100
String staking	2	0	4	5	0	0
Tripods	2	3	0	0	0	0
No stakes	0	0	8	5	0	0

2.4 Planting and staking practices

Table 5. Climbing bean planting and staking practices on farmers' own *plots. This table includes all farmers (also those with incomparable N2A and own plots and were therefore not visited a second time for yield measurements).*

Own plots	Row spacing (cm)		Plant spacing (cm)		Nr of plants per hole	
District	*μ ± SE*	*N*	*μ ± SE*	*N*	*μ ± SE*	*N*
Kapchorwa	68 ± 2	19	NA		5.6 ± 0.5	39
Kabale	41 ± 4	18	34 ± 2	20	3 ± 0.5	20
Kanungu	51 ± 2	8	21 ± 2	33	1.6 ± 0.3	33

Own plots	Nr of stakes on 4 m^2		Nr of plants per stake		Stake length (cm)	
District	*μ ± SE*	*N*	*μ ± SE*	*N*	*μ ± SE*	*N*
Kapchorwa	8 ± 1	39	5.9 ± 0.34	39	172 ± 3	39
Kabale	11 ± 1	20	4.1 ± 0.5	18	157 ± 5	18
Kanungu	12 ± 1	33	6.5 ± 0.4	33	167 ± 4	33

*Table 6. Practices on farmers' N2A plots compared to the recommended practices. Significance levels (Sig).: '***' for P<0.001; '**' for P<0.01; '*' for P<0.05. This table includes all farmers (also those with incomparable N2A and own plots and were therefore not visited a second time for yield measurements).*

N2A plots	Row spacing (cm)			Plant spacing (cm)			Nr of plants per hole		
Recommended:	*50 cm*			*25 cm*			*2*		
District	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*
Kapchorwa	64 ± 2	29	***	NA			4.5 ± 0.3	51	***
Kabale	48 ± 4	25		29 ± 1	25	***	2.2 ± 0.1	25	
Kanungu	50 ± 2	33		30 ± 1	34	***	2.3 ± 0.1	34	*

N2A plots	Nr of stakes on 4 m^2			Nr of plants per stake		
Recommended:	*16*			*4*		
District	*μ ± SE*	*N*	*Sig.*	*μ ± SE*	*N*	*Sig.*
Kapchorwa	8 ± 0	51	***	4.8 ± 0.4	50	*
Kabale	12 ± 1	25		3.3 ± 2.3	23	*
Kanungu	15 ± 1	34		4.1 ± 0.2	21	

Table 7. Significant differences in management between the N2A *and the* own *plots of farmers. Significance levels (Sig.): '***' for p<0.001; '**' for p <0.01; '*' for p<0.05, resulting from a one-way ANOVA. '-' signifies that data were not available. This table includes all farmers (also those with incomparable N2A and own plots and were therefore not visited a second time for yield measurements).*

District	Row spacing	Plant spacing	Nr of plants per hole	Nr of stakes on 4 m^2	Nr of plants per stake	Stake length
Kapchorwa		-			**	
Kabale		*	**	***	**	
Kanungu		***	***	*	***	

Table 8 –Overview of the significance of differences in management between the N2A *and the* own *plots of farmers. Significance levels (Sig.): '***' for p<0.001; '**' for p <0.01; '*' for p<0.05, resulting from a one-way ANOVA. '-' signifies that data were not available. This table is based on data only from farmers where the yield was measured.*

District	Row spacing	Plant spacing	Nr of plants per hole	Nr of stakes on 4 m^2	Nr of plants per stake	Stake length
Kapchorwa		-				
Kabale				***		
Kanungu		***	**	*	***	