Putting Nitrogen Fixation to Work for Smallholder Farmers in Africa

MSc. Internship report

PPS-70424 MSc Internship Plant Production Systems

Soya ni Pesa

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Chapter 1. Introduction

This academic report was written in fulfilment of the academic requirements pertaining to guidelines for an Internship in the Plant Production Systems chair group (PPS) at Wageningen UR. The internship was carried out under the auspices of the N2Africa project and took place in the Southern Highlands Tanzania with the Catholic Relief Services (CRS) project of Soya Ni Pesa (SnP).

N2Africa

N2Africa is a large scale, science research project focused on putting nitrogen fixation to work for smallholder farmers growing legume crops in Africa (N2Africa, no date). The project is funded by "The Bill & Melinda Gates Foundation" and 'The Howard G. Buffet Foundation' through a grant to Plant Production Systems, Wageningen University, who lead the project together with CIAT-TSBF, IITA and many partners in the Democratic Republic of Congo, Ghana, Kenya, Malawi, Mozambique, Nigeria, Rwanda and Zimbabwe. Currently, new partnerships are established in Ethiopia, Uganda, Tanzania, Liberia and Sierra Leone.

The project directly links the atmospheric reserves of nitrogen to the protein and nitrogen needs of poor African farmers. It aims to improve farm household welfare by raising the average yields of grain legumes by 954 kg/ha in four legumes (groundnut, cowpea, soybean, and common bean) and to increase average biological nitrogen fixation (BNF) by 46 kg/ha. Goals to be achieved at the end of the 4-year project are to:

- identify niches for targeting nitrogen fixing legumes
- test multi-purpose legumes to provide food, animal feed, and improved soil fertility
- promote the adoption of improved legume varieties
- support the development of inoculum production capacity through collaboration with private sector partners
- develop and strengthen capacity for legumes research and technology dissemination
- deliver improved varieties of legumes and inoculant technologies to more than 225,000 smallholder farmers in eight countries of sub-Saharan Africa.

Soya ni Pesa

The Soya ni Pesa (Soybean is Money) project is an initiative to strengthen the soybean value chain in Tanzania's Southern Agricultural Growth Corridor (SAGCOT), by working with smallholder farmers and integrating them with markets. During the four years of the project CRS invests United States Department of Agriculture (USDA) funds to increase the production of soybean from 3,500 MT per year to 11,000 MT and to support a total of up to 11,250 local farmers in the process. The project will upgrade the feed component of the Tanzanian poultry sector, with special attention to building a competitive supply of soybean for oil and meal production.

The two main objectives are:

- to increase agricultural productivity in the egg and soybean value chains by demonstrating improved production techniques, facilitating access to improved seed, and linking agricultural producers to financial services and agro-dealer networks
- to expand trade of agricultural products in the egg and soybean value chains by training agricultural producer groups, facilitating access to storage facilities, and linking agricultural producers to markets and market information.

These objectives will be achieved by ten major interventions/activities (Figure 1).

Background

Low and declining soil fertility is widely recognized as a major constraint limiting smallholder farming systems in sub-Saharan Africa (FAO, 2012, Okalebo et al., 2006). In many areas low soil fertility is the result of continuous cropping, minimal use of fertilizers and a shift away from the traditional systems that included fallow, which allowed the soil to recover from several years of cropping (Smaling et al., 1997). Restoration and maintaining soil fertility therefore is a major challenge to ensure food security. Conventional methods to increase soil fertility are the use of fertilizers and manure, but use by smallholders is often restricted due to high costs, unreliable returns, lack of credit, market access etc. (Sanchez, 2002). In the past governments periodically ran successful fertilizer and seed subsidy programs, but these are unsustainable in the long run because of the high costs involved (Sanchez et al., 1997). Moreover, removal of such subsidies caused fertilizer prices to surge in relation to the prices of crops.

Alternatively, many legumes can nodulate and fix atmospheric nitrogen abundantly by the symbiotic association between the crop and soil bacteria (rhizobia) (Giller, 2001). Nodulated legumes have the potential to fulfil their demand for nitrogen by fixation and, as a result, can influence the nitrogen balance of the soil (Hardarson and Atkins, 2003). Thus, growing legumes may increase availability of nitrogen to accompanying or succeeding crops and intensification of nitrogen-fixing legumes may provide an agronomic and economically sustainable alternative

(Kaschuk et al., 2006). At the same time sustainability will be improved by the diversification of the cereal dominated rotations.

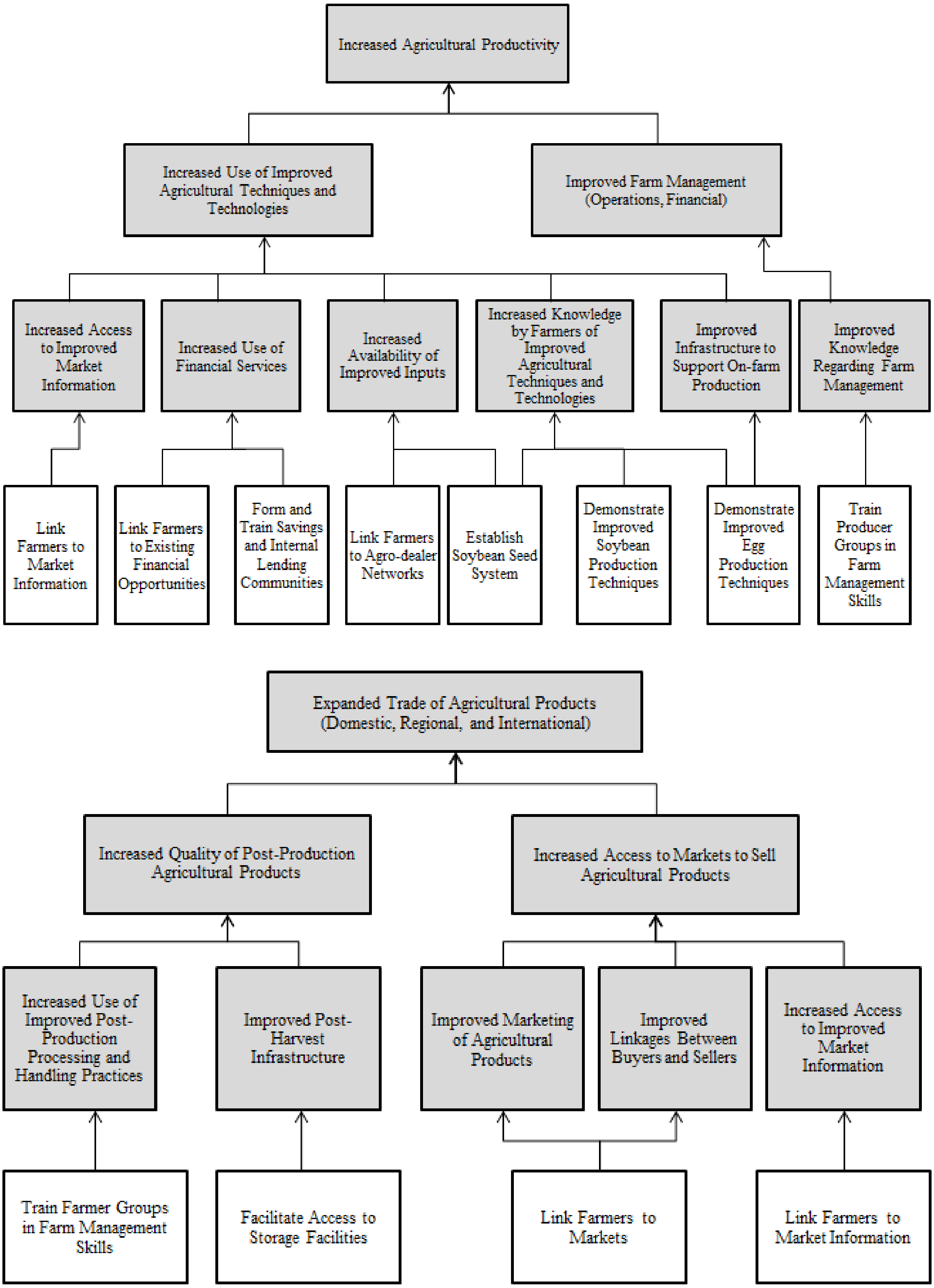

Figure 1 SnP framework for interventions and results.

Besides their potential to contribute to soil fertility grain legumes are often valued as being the "meat for the poor" because of their high protein content and the low prices of pulses compared with meat (Kaizzi et al., 2012). They complement other foods such as maize by which they can play an essential role in human nutrition. Furthermore, while addressing the nutritional security of the households legumes can also provide opportunities for farmers to improve their income (Giller et al., 2011).

Internship objectives

The objective was to observe and collect data as a 'fly-on-the-wall' in order to better understand the SnP project and its challenges. Apart from initially getting acquainted with the project and the people involved, the internship activities can be divided over three main activities, during which data was collected:

1. Work closely with a Field Extension Officer (FEO) at the village level; meet with and talk to actors and farmers involved in the project.
2. Walk along with the officers at the regional level; understand the project from the perspective of the local organisations.
3. Field visits, workshops, trainings with the SnP agricultural officer from Dar es Salaam; field measurements, data collection, training of FEO's and volunteers, monitoring progress.

Figure 2 provides a general description of how the project is organised and, hence, at what level each activity took place.

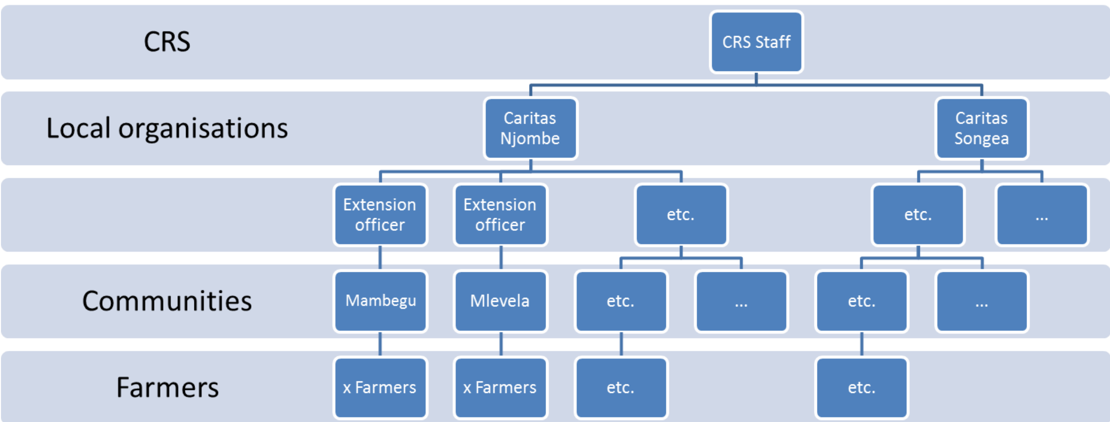

Figure 2 Overview of SnP project structure.

Outline

The following chapters were written to provide an overview of all experiences and findings. First Chapter 2 further explains about the project and describes the projects locations. Then, Chapter 3 describes some of the main findings. After, Chapters 4 – 7 present a series of short papers on the collected data, each supplemented with some final comments. Chapter 8 provides an overview of the challenges and opportunities. Finally, a reflection is added after the Appendices.

Chapter 2. Project locations

The SnP project will take place in three regions, Njombe, Ruvuma and Morgoro, all in the Southern Highlands of Tanzania, but currently only the previous are included (Figure 3). CRS office is located in Dar Es Salaam and the organisation of the project on the regional and village level works directly via Caritas Njombe and Caritas Songea.

Figure 3 Map of Tanzania. Encircled in red the area where the project currently takes place.

Rainfall in the Southern Highlands is monomodal. The period between June and October is a low rain or no rain season and therefore little agricultural production takes place. In some places small scale irrigated production still takes place in the 'vinyungu' gardens in the valleys, but these are usually much smaller in size. In many cases these vinyungus are used for seed multiplication of beans for instance. Slash and burn agriculture is visibly practiced throughout the area. The main staple crops are maize and beans. In terms of production the second crop, after maize, varies from location to location and by agro ecologies. Apart from beans large crops are sunflower, simsim, rice, tobacco, tea, etc.

Figure 4 presents the agro-ecological zones of both Songea district and Njombe district. Additionally, Table 1 provides the legend needed to interpret the codes displayed in each of the maps (Ministry of Agriculture Food Security and Cooperatives, no date).

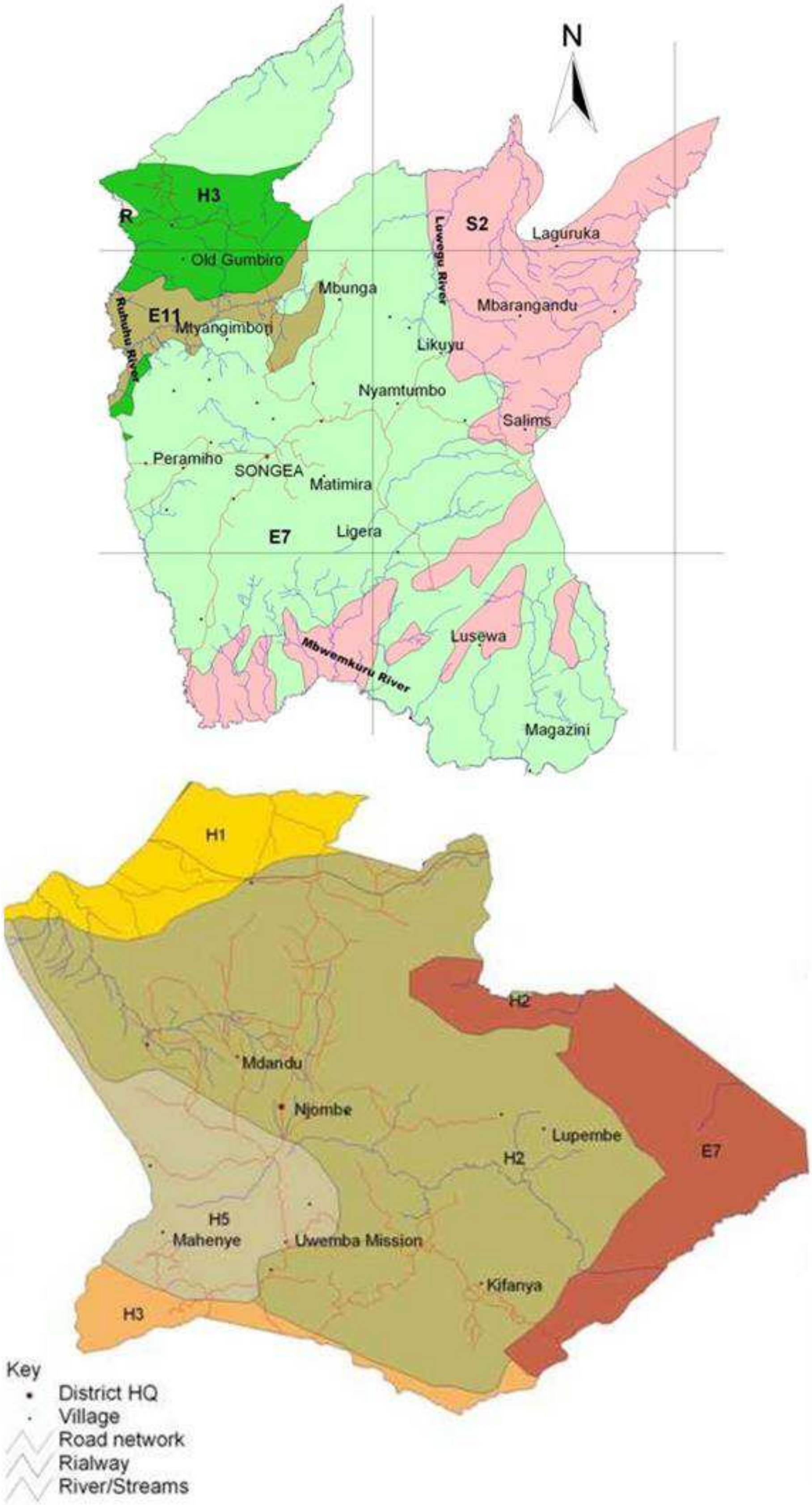

Figure 4 Agro-ecological maps of Songea district (top) and Njombe distric (bottom) (Based on Ministry of Agriculture Food Security and Cooperatives, no date).

Table 1 Description of the Agro Ecological Zones of Songea districs and Njombe district as presented in Figure 4 (Based on Ministry of Agriculture Food Security and Cooperatives, no date).

AEZ CODE	SUB ZONE-AREA (Sq-Km)	pH (H_2O)	Temperature (°c)	Soils and Topography	Altitude (m)	Rainfall total (mm/Year) / Patten	Length of Growing Period and Soil Moisture Properties
E7		5-6½	27-30 15-18	Mainly well drained, flat to rolling plains, locally hilly at medium altitude (750-1300 m). 30% is strongly dissected uplands and low hills transitional to the medium altitude plateau. Major soils are well drained, moderately deep to deep dark red to red to friable clays with moderate to strong structure and evidence of clay illuviation. Natural soil fertility is low to moderate, with common problem of soil acidity.	800-1500	800-1000 Monomodal	One medium to long DGP with reliable onsets per year with duration of 5-7 months in most of the zone, varying by 1½-2 months depending on soil moisture storing capacity and crop rooting habits. Moderate moisture storing properties (good rainfall acceptance, lateral seepage water addition) poor to moderate water storing properties depending on the presence of chemical barriers (AWC 80-120 mm/m, Smax 30-70 with chemical barriers, Smax 100-300 without chemical barriers)
E11		5-7	27-31 15-23	Complex depressions composed of dissected ridges, fault scarps and alluvial plains; low to medium altitude. Mainly covered by well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth. Natural fertility is low to very low.	500-1000	1000-1200, Monomodal	One DGP per year with duration of 5 – 6 months, varying by 1 month depending on soil moisture storage capacity and crop rooting habits. Onset dates are reliable. Moisture storing properties ranges from low to moderate (AWC 50-80 mm/m, Smax 50-150 m). The soils have goof rainfall acceptance.
H1		5-7	22-25 10-15	Mainly flat and undulating to rolling plains and plateaux at high altitude, developed on granites and gneisses. Major soils are well drained, deep yellowish or reddish sandy clays to clays with moderate to strong structure, with moderate natural fertility; and well drained, moderately deep to deep, reddish and yellowish sandy loams and sandy clays, often with more sandy topsoils, with weak structure and low natural fertility.	1500-2000	600-1600 Monomdal	One DGP per year with duration of 5-6 months depending on soil moisture storage capacity and crop rooting habits. The zone has reliable onset dates, moderate AWC (120 mm/m) and favourable moisture storing properties (Smax 300-400 m).
H2		5-7	22-25 10-15	Undulating to rolling plains at the high altitude developed on granites. Major soils are well drained, deep yellowish or reddish sandy clays to clays with moderate to strong structure, with moderate natural fertility; and well drained, moderately deep to deep, reddish and yellowish sandy loams and sandy clays, often with more sandy topsoils, with weak structure and low natural fertility.	1500-2100	1400-1600 Monomodal	One DGP per year with duration of 6-9 months depending on soil moisture storage capacity and crop rooting habits. Reliable onset dates, moderate AWC (120 mm/m) and favourable moisture storing properties (Smax 300-400 m).
H3		4½-7	22-25 10-15	Mainly strongly dissected hills and mountains at high altitude strongly susceptible to erosion and landslides. Major soils are well drained, moderately deep to deep, reddish and yellowish sandy loams and sandy clays, often with more sandy topsoils, with weak structure and low natural fertility.	1500-2300	1000-1400 Monomodal	One DGP per year with duration of 6-9 months depending on soil moisture storage capacity and crop rooting habits. Reliable onset dates, moderate AWC (120 mm/m) and favourable moisture storing properties (Smax 300-400 m).
H5		5-7	22-25 10-15	Volcanic landforms ranging from undulating to rolling, medium to high altitude plains and plateaux; to strongly dissected hills, mountains, plateaux and plains at medium altitude. Major soils are well drained, deep, dark grey brown loamy sands, sandy loams and loams rich in allophanic clays with weak structure, low bulk density and with high natural fertility; and well drained, deep yellowish or reddish sandy clays to clays with moderate to strong structure with moderate natural fertility.	1200-2400	1000-2000 Monomodal	One DGP per year, increasing in duration from 6-9 months to 9-12 months, depending on altitude and soil moisture storage capacity. Onset dates difficult to determine because of overlap of growing periods. Soil moisture characteristics vary between physiographic units ranging from moderate to high AWC (100-200 mm/m) with favourable moisture storing properties (Smax 300-400).
S2		5-7	27-31 15-23	Mainly gently undulating to rolling plateaux developed on Karroo sediments. Some parts of the zone strongly dissected terrain. Dominant soils are well drained, moderately deep to deep, red, yellowish red or orange sands and loamy sands with sandy loams in depth, weak structure and very low natural fertility; and proportion of moderately well to imperfectly drained, deep, brown, pale yellow, light grey or white mottled sands and loamy sands with weak structure and very low natural fertility	200-1000	1000-1200 Monomodal	One DGP per year with duration of 5-7 months, varying by 1-2 months depending on soil moisture storing capacity and crop rooting habits. Reliable onset dates. The zone is mainly covered by moderately deep sandy and loamy soils with low to moderate AWC (50-80 mm/m) and poor to moderate moisture storing properties.
R		na	na	Rocky terrain	na	na	na

Caritas Njombe

Njombe district inhabits over 420,000 people in approximately 99,000 households and consists of a total of 25 wards (Tanzania National Website, no date). Currently the villages of Ikondo, Mambegu, Mlevela and Nyave are included in SnP, in which a total of 112 households participate (Figure 5).

An interesting other project also ran via Caritas Njombe, in collaboration with Heifer international. Families received a heifer and became donors themselves as they passed the next generation to other families in need. This project ended recently, but there are still many households waiting in line, interested to participate. Subsequently, some villages were already well known and, hence, the choice to start the SnP project in the current villages was influenced by this history.

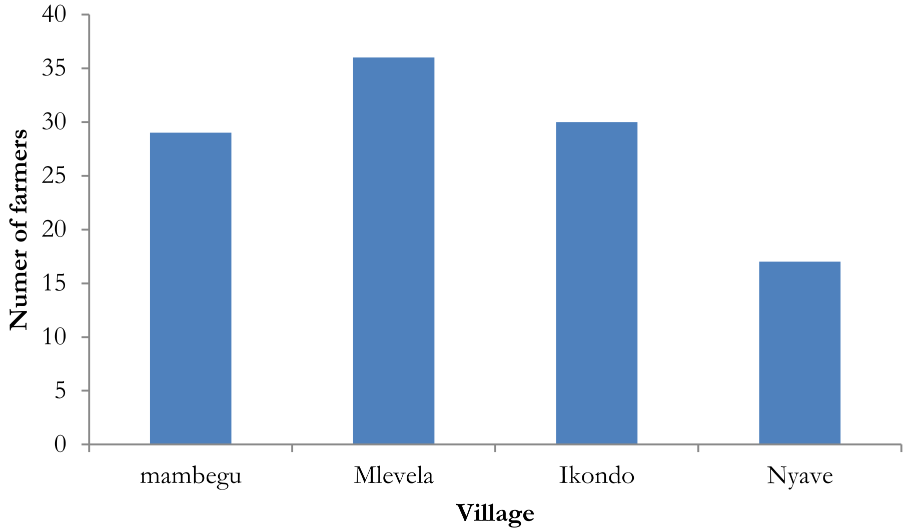

Figure 5 The villages in Njombe region that are currently included in the SnP project. For each village the number of households that are in the project is given. Total number of households: 112.

Caritas Songea

In Ruvuma region SnP is organised via Caritas Songea. The project includes the districts of Songea Rural (pop. 148,000; 32,000 households) and Namtumbo (pop. 185,000; 33,000 households) (Tanzania National Website, no date) .

A total of 282 households from the villages of Chengena, Namanguli, Mkongo gulioni, Limamu, Hanga, Mbimbi, Sinai (Namtumbo district), Liganga, Nakahegwa, Madaba, Mkongotema (Songea Rural district) are included (Figure 6). This number is meant to increase to 2752 in the following season and up to 4065 by the third year. By then 14 villages should be included in Namtumbo, and 13 in Songea Rural.

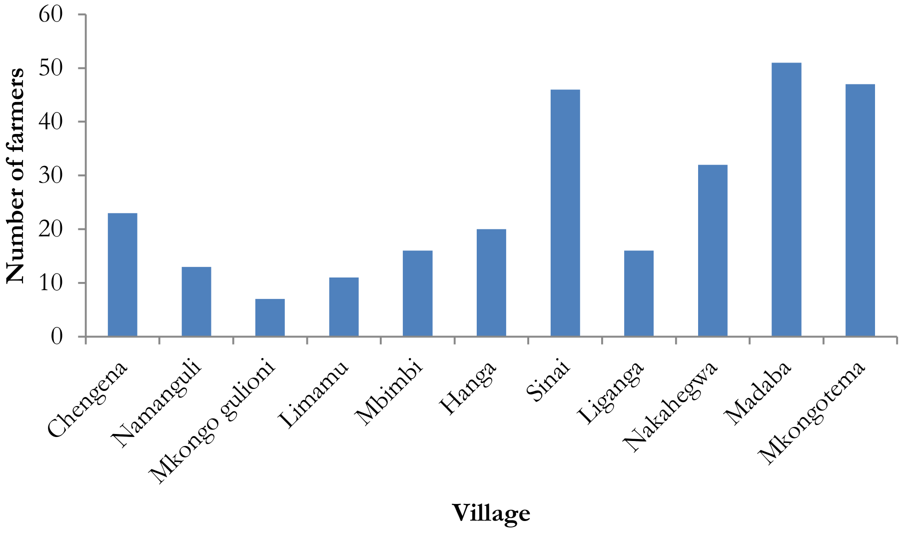

Figure 6 The villages in SnP project and the number of households for each village (Ruvuma region). Total number of households: 282

Chapter 3. Findings

When I arrived in Tanzania I spent the first day in the CRS office in Dar es Salaam to get familiarised with the project, the planning for the next days, etc. The day after I travelled to Njombe, from where I was transferred to Ikondo to spend some time with the local Field Extension Officer for Ikondo and Nyave. After several weeks I returned to Njombe to grasp some of the project on the regional office level and joined on visits to each of the villages. Finally I joined Lembris Laiser, the SnP agricultural officer, on a series of field visits, demonstrations and workshops in both Njombe and Songea.

Overall most time was spent on: 1. Walking along and talking to farmers; and 2. Measurements in the field. This chapter presents a selection of findings I believe to be noteworthy. Several other findings will be presented in Chapters 4-7 and will therefore not be further described here.

Farmer selection

- In Ikondo and Nyave soybean cropping takes place in groups that were originally established by CEFA (an Italian development organisation in Ikondo) for a project in sunflower production. They were formed by approaching some already known women to become group leader and by having them find interested group members. Hence, the groups were designed to boost women empowerment. CEFA was open to also introduce soybean production so the groups were approached for growing soybean as well. In all other villages soya is grown independently. The farmers that are currently in the project in Mambegu and Mlevela were already known by Caritas Njombe from the heifer project briefly mentioned in Chapter 2.

Soybean history

- Soybean is a crop that is already known amongst farmers, especially in Ruvuma region. In many locations farmers have a history of growing a local soybean variety, or in fact still are. In Ikondo soybean was introduced several years ago, but the buyer pulled out of the project after a conflict with local government. Hence, the market for soybean disappeared abruptly. Farmers do not have any knowledge about other functions of soybean and had no choice but to burn their harvests. As a result farmers are very reserved about growing soybean. To convince them CEFA offered the groups to use CEFA lands instead of their own. In Songea too soybean was introduced multiple times, but the projects were never really backed up. As a result farmers have a lack of trust and plant the SnP crop on marginal lands.

Farming systems

- In all locations farmers typically use a rotation system with two major crops: maize and beans, sometimes in combination with fallowing. One exception is the (relay)intercropping system that was observed in Mambegu, where farmers generally grew maize, beans and cowpea. First beans are harvested, then maize and finally the cowpea, that use the maize stalks to climb due to their vining habit.

- In addition, the improved heifers from the Heifer project briefly mentioned in Chapter 2 (in Mambegu and Mlevela, Njombe district) were kept in a zero-grazing system, whereas local breeds graze on communal lands.

Project timing

- The late launch of SnP showed up in an appearance of a somewhat chaotic project organisation. For instance, in Ikondo, groups had cultivated their land in December but the seeds had not yet been supplied. Moreover, distribution was further delayed because transport to the villages became impossible because of heavy rains: roads were simply too muddy. By the time the seeds finally arrived, weeds had regrown and lands had to be prepared for a second time, yet farmers were now active in undertaking other activities. Likewise, the inoculants arrived late. As a result, project staff often seems to be one step late with many tasks and are mostly busy fixing things, rather than moving forward to a next phase.

Inoculants

- Knowledge about inoculants is inadequate. The information provided in the workshop about *Rhizobium* only partly reached its audience. Possibly this was a result of too much information that was to be taken up in one go. Furthermore, the text on the bags that were distributed is written in Czech, which is clearly not spoken by anyone in the project. This was due to the emergency ordering of the inoculant by N2Africa, so any 'on the shelf' product could be sourced. Consequently some important information did not reach the farmers.

- The inoculant was supplied in bags of 2.5 kg whereas the majority of farmers plants less than 10 kg of seeds. Therefore they only require a maximum of 40 grams, or, often, less than that. Distribution takes place by taking little quantities from the 2.5 kg bags and handing them out it in a piece of paper, matchbox, plastic bag etc., thereby completely missing sterility considerations and the need to plant within 1-2 days. Furthermore, it is likely that the inoculant is stored by the farmer between time of distribution and time of planting. Both may lead to *Rhizobium* dying off, thus a failing product.

- Farmers in Namanguli explained that a local research station (ARI Uyole) already introduced *Rhizobium* at the beginning of the previous season. When some of the fields became diseased and/or showed high mortality farmers feared the product to be toxic. Now, the majority of farmers did not use inoculant this season, even though they have received them. What is striking is that originally this information did not reach the Caritas FEO and/or the SnP project staff.

FEO functioning

- It seems there is a considerable gap between FEOs and farmers in the majority of villages. While visiting many villages with Lembris it became apparent that most FEOs are struggling in both the documentation of farmer data and communicating project knowledge to farmers. The tools they were supplied with in order to support them in their work, such as a handbook, are little made use of.

- Although it is improving, on the regional scale there is still a lack of knowledge about and controlling of FEO activities. Many issues did not come to light until Lembris and I started visiting the fields. We went through great lengths to gather simple data such as the quantity of seeds sown, date sown and date weeded. Furthermore, documentation of any activities such as new or improved practice/agronomic advice or meetings with farmers was usually absent.

- In addition reliability of information provided forms a major factor of concern. One of the most striking stories is a FEO who presented field size data that soon turned out to be the result of cross multiplication: field size (acres) = kg of seeds received × acres per kg of seeds (based on recommended spacing).

- In Ruvuma region Caritas ended up recruiting 15 helper farmers, who received a two-day-training, in order to ensure that at least the main tasks of FEOs were to be completed. This turned out to be a very effective way of gathering important data, but it ignored the more fundamental problem which is that the FEOs did not fully do or understand their tasks. On top of that it places local farmers in a position where they financially compensated by the project. This is not necessarily a problem, but I believe caution is advised because it may raise some (long term) financial expectations.

Field size measurements

- In many locations field measurements were not completed or often were imprecise. Common methods used to measure fields were the counting of steps, sticks, pieces of string, etc. In some cases it was shown that field size had been overestimated up to 20%. After a thorough inspection it was concluded that a substantial part of the area of soybean that had originally been recorded had to be written off because it had never existed.

Travel

- Transport forms a major obstruction for the FEOs to successfully fulfil their tasks. In both Njombe and Ruvuma region I discovered that several FEOs had only seen some fields once, up to months earlier. I do not attribute these facts to a lack of transport options only, because I believe attitude plays a major part. Nevertheless, while staying in Ikondo I repeatedly experienced having to spend considerable time on travel and, moreover, arranging a mode of transport. In particular travel to and from Nyave, over 20 kilometers from Ikondo was a constant challenge. It was not uncommon to be waiting at least half a day for transport. As a result several planned meetings were missed and had to be rescheduled. The lack of signal for mobile communication further exacerbated the issue because any delays could not be communicated.

Weather

- Farmers in Songea Rural indicated drought at time of sowing and/or time of flowering have influenced crop performance. Rainfall data from two sources (ARI Uyole substation based in Namtumbo and Caritas advisor based in Songera Rural) also suggest a lack of rains during this period (Figure 7).

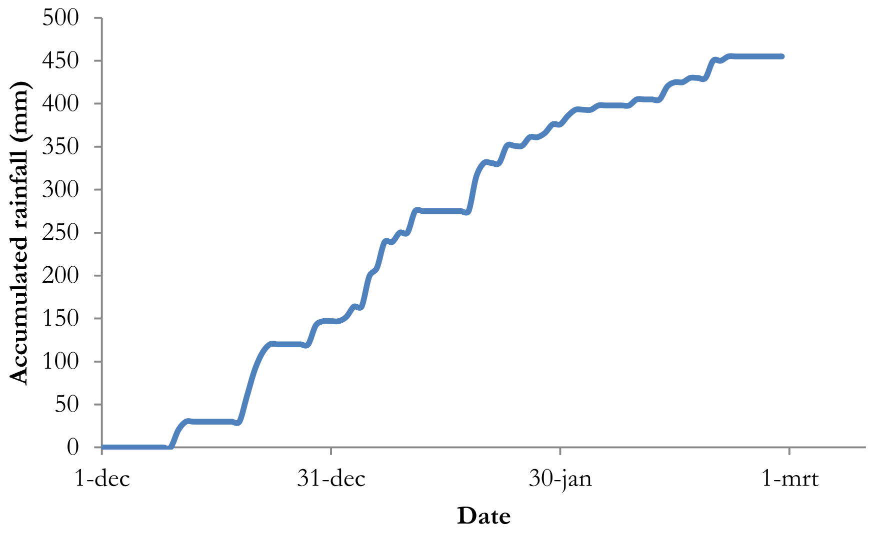

Figure 7 Accumulated rainfall data collected by a Caritas advisor in Songea rural.

Chapter 4. Nodulation assessment of demo plots of soybean (*Glycine max*) in the Soya Ni Pesa project in the Southern Highlands of Tanzania.

Abstract

Within the Soya Ni Pesa (SnP) project demonstration plots were formed with the goal of demonstrating a set of improved soybean production techniques to local farmers. Six well-established plots were selected and nodulation was scored and recorded for each plot. Results showed nodulation to be significantly greater with (Brady)rhizobial inoculation, alone and in combination with 120 kg DAP ha^{-1}. A combined application of inoculant and P fertilizer may be most profitable, but more research is needed to confirm. Furthermore, additional soil sampling may provide more insight in environmental constraints. Finally, it is believed that, when well taken care of, the demo plots provide a powerful tool to convince farmers to change their management.

Introduction

As part of a program to upgrade the Tanzanian poultry feed sector the Soya Ni Pesa project (SnP) aims to increase the production of soybean (*Glycine max*) in the Southern Highlands of Tanzania. Up to 11,250 farmers will be supported in the four year project with the objective of increasing agricultural productivity, diversifying outputs, increasing smallholder incomes and improving soil fertility.

Several demonstration plots were established (Figure 8) with the goal of demonstrating improved soybean production techniques to local farmers. In principle where targeted groups are located within ten kilometres of one another, CRS intended to establish one demonstration plot for every three to four producer groups. Where groups are not located within ten kilometres of one another, one demonstration plot was to be established for each group. Field extension workers can work from these plots to explain to farmers the types of technology options they can use. Nodulation assessment was executed for reliable demo plots that included inoculation as a treatment.

Materials and Methods

SnP recommended spacing for soya production is 0.45 m inter-row and 0.05 m intra-row. Hence, demonstration plots were established to display this spacing, adjacent to conventional farmers' spacing, which provided a tool to compare different management options. Accordingly, when farmers observe and realize what practice is the best one they may decide to adopt their management in the next season. Besides spacing, several other treatments were also presented:

1. Control (no treatment)
2. DAP
3. inoculation
4. DAP + inoculation
5. Minjingu Rock Phosphate
6. Minjingu Rock Phosphate + inoculation

The actual presented management options varied largely for each location. For instance, due to late arrival of the inoculants not all demo plots included the inoculation treatment. Similarly, Minjingu Rock Phosphate was not included in many demonstration plots in Ruvuma region. All plots were planted with the projects' variety: Uyole soya-1.

Figure 8 Example of a demonstration plot (Picture take at Chengena village, Namtumbo). In the front an uninoculated plot of soya. In the back inoculated soya + DAP (120 kg ha^{-1}).

Nodule assessment

Only well-established demo plots were selected for nodulation assessment. Criteria for this selection were 1. reliable demo plot formation (treatment design and establishment, same date of planting, record keeping) and 2. proper management (preparation, weeding). In practice this meant six plots in Ruvuma region were selected of which their formation was closely supervised by CRS. Figure 9 provides a graphical representation of the plot design and their included treatments. Minjingu Rock Phosphate was not included in any of these specific plots.

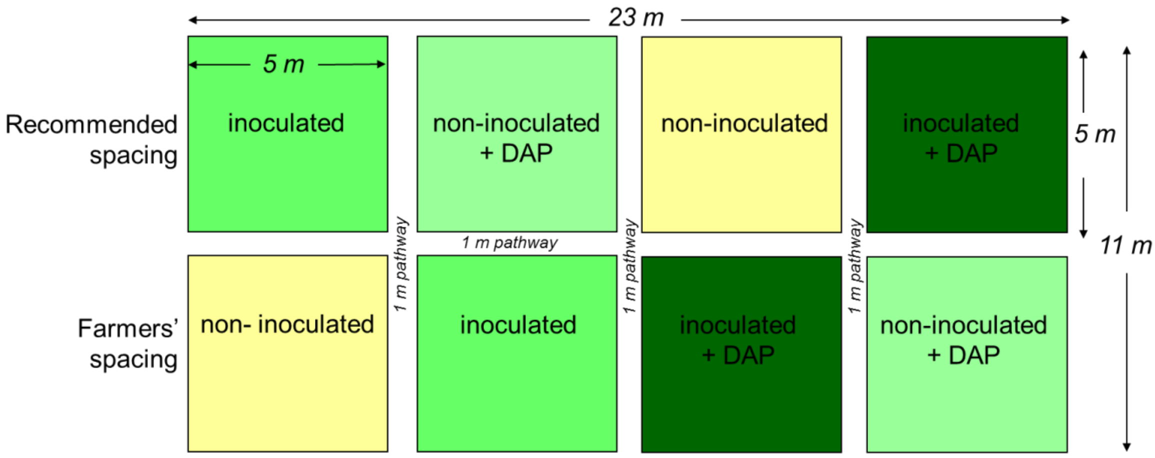

Figure 9 Graphical representation of plot design. Note that the locations of each fertilizer treatment were randomized within each spacing type. Amounts of DAP equal to 120 kg ha^{-1} and inoculation rate of 4 g kg^{-1} of seed.

Nodulation was scored and recorded for each plot, based on the system devised for soybean in the N2Africa project (Figure 10). Three plants were randomly selected from each plot at time of flowering and dug up in such a way that the root system and nodules were recovered. The scores from all plants were added and then divided by three to obtain a mean nodule score. A mean nodule score of: 4 - 5 represents excellent nodulation; excellent potential for nitrogen fixation 3 - 4 represents good nodulation; good potential for fixation 2 - 3 represents fair nodulation; nitrogen fixation may not be sufficient to supply the N demand of the crop. 0 - 2 represents poor nodulation, little or no nitrogen fixation.

All the data were subjected to Analysis of Variance (ANOVA) using the ANOVA Procedure of Genstat version 15 and differences among the treatment means compared using Fisher's Protected LSD test at 5% probability level.

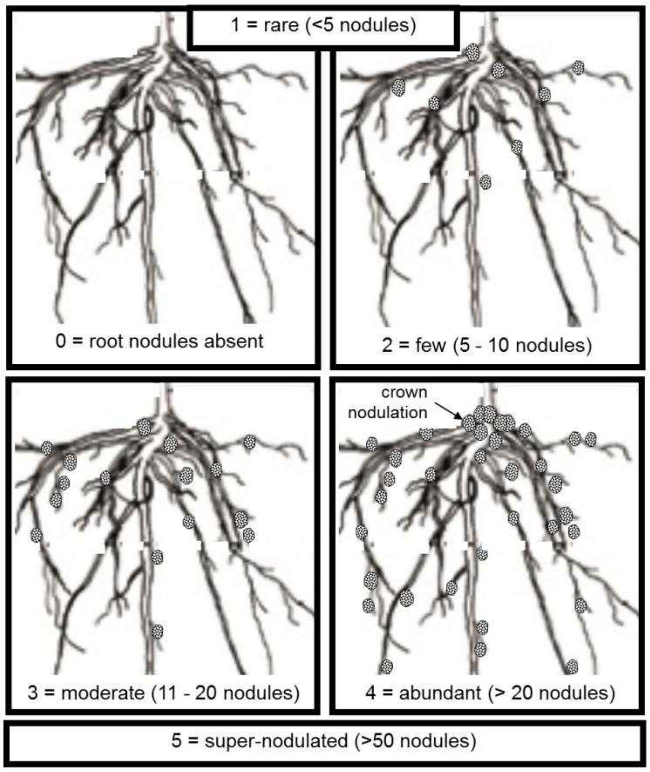

Figure 10 Diagrammatic representation of the visual classification criteria used to evaluate the root system of soybean. Nodule score is judged by the number of effective nodules in the system (From N2Africa, 2012)

Results

Overall nodulation of soybean was poor for the control treatments at all sites (Table 2). Nodulation was significantly greater with (Brady)rhizobial inoculation, whether alone or in combination with 120 kg DAP ha^{-1}. Application of 120 kg DAP ha^{-1}also increased the number of nodules. At Mkongotema and Sinai nodulation was particularly poor even in combination with inoculation.

Table 2 Average nodule score of soybean under different technologies at six demo plots in SnP project.

	Location						
Treatment[a]	**Chengena**	**Namanguli**	**Mkongotema**	**Madaba**	**Sinai**	**Nakahegwa**	**Mean**
0	1.00	0.17	0.00	0.00	0.00	0.33	0.25a
DAP	1.67	1.17	0.17	2.17	0.50	0.50	1.03b
Inoculation	2.83	2.17	0.67	2.00	0.50	2.00	1.69bc
DAP + Inoculation	3.17	2.83	0.67	2.71	0.67	1.67	1.95c

P<0.001,Standard Error=0.376 for the means
[a] Treatments 0=Control (no treatment), DAP= 120 kg DAP ha^{-1}, Inoculation = 4 g inoculant kg^{-1} of seed

Discussion

Inoculation with *Bradyrhizobium* increased nodulation of soybean at all sites, revealing population of indigenous rhizobia which could nodulate soybean was not sufficient (Figure 11). This outcome is consistent with findings by Chowdhury *et al.*(1983), who found an increase of nodulation as a response to inoculation in Morogoro. In this research highest grain yield increase due to inoculation was similar to that obtained by the application of 90 kg N ha^{-1}.

Figure 11 Roots of inoculated (left) and uninoculated (right) soya plants (Chengena village, Namtumbo).

A similar result was found in Northern Tanzania in Rombo and Moshi by Ndakidemi *et al.* (2006), with increases of grain yields of 127-139% as a response to inoculation alone. In combination with an application of P (26kg P ha^{-1}as triple super phosphate) grain yields increased by up to 207-231%, significantly higher than the use of N (30 kg N ha^{-1} as urea), P or inoculation alone. Likewise, P was shown to be limiting nodulation of *Phaseolus vulgaris* in northern Tanzania (Giller et al., 1998, Amijee and Giller, 1998). In the demo plots application of DAP increased nodulation. Although not significant, the combination of DAP and inoculation also performed better than inoculation alone, hinting at phosphorus being a limiting factor for nitrogen fixation. Therefore, in the next year it would be worthwhile including a Minjingu Rock Phosphate treatment in all demo plots.

This is further emphasised by the former mentioned findings by Ndakidemi *et al.*(2006), who also analysed the economic benefits of the technologies used. In their research the combined use of P and inoculants increased profits up to 224 and 250% over the control, much more than the increase by the use of mineral N (79-87%), P (45-73%) or inoculation (140-153%) alone. Hence, the simple use of inoculants has the potential of improving resource poor farmers' lives, and the importance of promoting its use should not be underestimated.

In Mkongotema and Sinai the response to inoculation was small. For both these locations field observations revealed a green and vigorous crop, regardless of treatment. Therefore, local circumstances were likely to sufficient to support crops growth and the soil was probably high in nitrogen, which is commonly known to depress nodulation when available in high amounts (Giller, 2001).

Soil analysis indicates soils are deficient in K in southern Tanzania (Smithson et al., 1993). No potassium treatments were included nor were soil samples taken for these demonstration plots so it is unclear if this matter also plays a role here. Similarly, soil acidity is known to reduce the survival of rhizobia in soil, inhibit nodulation and N_2-fixation and, leads to P fixation and increases aluminium toxicity and calcium deficiency (Giller, 2001, Hungria and Vargas, 2000). Subsequently, taking soil samples may increase the understanding of the soils in question and could lead to a better diagnosis of their corresponding issues. In turn the knowledge of these environmental constraints will provide a tool to better support local farmers in their production.

Figure 12 Demo plot visit with local farmers at Madaba village.

Finally, while visiting these six demo plots alongside farmers it was clear that farmers' attitudes towards these plots were overall very positive. Several farmers indicated the plots convinced them to adapt their management for the next season and increase plant density for instance (Figure 12). This may well rub off on neighbouring farmer in the years to come. However, it seems this attitude will stand or fall with the credibility of the plot in question, because farmers' responses were clearly more meagre at plots that were compromised in some way. In Ikondo for instance plot size was reduced and did just not have the same glow of professionalism. Hence, establishing and enforcing well maintained plots, and eye for detail will improve the outcome. On top of that the initial investment in taking good care of a demo plot may lighten the job of the extension agents in the long term, because the management options in the plots will sell themselves.

Final comments

The six demonstration plots we did the measurements at were established with CRS supervision. The Minjingu treatment was not included because the P only treatment was not considered: farmer attitudes towards Minjingu is that it is a fertilizer that does not work, or only works in a next season. Essentially they one on one compare it to DAP. Hopefully our conversations, some papers I supplied and this report will increase some of the understanding of a potential combination of inoculation and Minjingu, rather than the view of it being an inferior fertilizer.

I feel the core problem is a lack of understanding of the legume-*Rhizobium* symbiosis. Talking to various people makes me realise the CRS staff training in December was simply too much to comprehend – saturation of taking up information. Especially the field agents do not seem to possess the knowledge of what inoculation is about, apart from a general picture of it being beneficial for crop growth.

Similarly I believe the essence of the demonstration plots – the tool to make farmers see what is possible – really just does not seem to have landed (until just now, hopefully). Field extension workers have just been planting them because they were instructed to do so. As a result, apart from the ones implemented under the supervision of CRS, all demo plots are poorly done. Just a few examples: lack of labelling or even no administration at all which treatment is which; no demarcation pegs making it hard to differentiate which plot ends where; seeds scorched by wrong application of fertilizer; treatments planted at a weeks' time difference; plots divided over two locations; no weeding or partly weeding; very tiny plots of only a few rows, etc. Some real encouragement is needed for extension workers to understand that taking some extra care will really benefit the project, and also ease their job in the long run, hence, why it is important to make these plots work.

The first demonstrations in Ikondo were poorly implemented. It appeared there had been little eye for detail and the plot in question was compromised in size. I think this may have spilled over to the FEO's in the whole region of Njombe. All plots in the region of Njombe made an impression of poor implementation.

Chapter 5. Germination of two lots of Soybean (*Glycine max* cv. Uyole soya-1) used in the Soya Ni Pesa project in the Southern highlands of Tanzania.

Abstract

Observations in farmers' fields in the Soya Ni Pesa project (SnP) raised suspicion about seed viability. To investigate whether seed germination may have been a factor influencing plant emergence seeds were subjected to a germination test under controlled conditions. Two seed lots used in SnP were collected from farmers and germination was tested under controlled conditions in the laboratory and in a pot experiment in a greenhouse. Average viability was 49.6 % and 2.9% for lot no's. 10811TAN208 and 10506TAN149 respectively. Both laboratory tests of seed lot no. 10506TAN149 showed severe fungal infection. This result, accompanied with a lack of germination in the greenhouse experiment, suggests this seed lot to be of inferior quality and a likely explanation for poor field performance. It is recommended to collect field data on what locations were planted to which lot number, and to check if poorly established fields correspond to this issue of seed viability.

Introduction

Observations in farmers' fields in the Soya Ni Pesa project (SnP) revealed a large variability of establishment between different locations. Several farmers indicated the SnP variety (Uyole1) displayed poor emergence and raised questions about seed quality, size and/or variety performance. Moreover, some farmers mentioned they were willing to participate in the project in future years, but suggested SnP to leave their variety at the office. They would prefer to grow their own, local, variety instead. A particular field in Hanga village, seeded with both Uyole soya-1 and a local variety revealed a well-established local variety but a poorly established Uyole soya-1 (Figure 13). The grower clarified both varieties had been planted on the same day, by the same person and essentially had received the exact same treatment, consequently variety being the only factorin this 'experiment'. Albeit lacking of replication, in combination with the observations in the project and farmers' opinion this raised suspicion about seed viability. To investigate whether seed germination may have been a factor influencing plant emergence seeds were subjected to a germination test under controlled conditions.

Figure 13 A field in Hanga village, with a well-established local variety (left) but a poorly established Uyole soya-1 (right).

Uyole soya-1

Uyole soya-1 was released in 2004 by the Southern Highland Zone Agricultural Research Institute (ARI Uyole). It is reported that at ARI Uyole, soybean yield is between 2 and 3.6 tonnes per hectare while under farmers' condition yields average at 1.5 to 1.8 tonnes per hectare (Malema, 2005). In SnP the seeds were supplied by ASA (Agricultural Seed Agency), a semi-autonomous body under the Ministry of Agriculture, Food Security and Cooperatives. The Agency was launched in 2006 and took over the responsibilities that were performed by the Seed Unit of the Ministry of Agriculture Food Security and Cooperatives and is aimed at ensuring availability of high quality agricultural seeds to farmers at affordable price. The project was supplied with three different certified seed lots (Table 3).

Table 3 Seed lots used in the SnP project and certified germination according to TOSCI (Official Seed Certification Agency, both under ministry of Agriculture, Food Security and Cooperatives).

Seed lot no.	Certified germination (%)
10506TAN149	88
10811TAN208	84
20144TAN197	99

Materials and Methods

Two out of three seed lots could be retrieved from farmers. Each lot was tested in a Petri dish (20 seeds dish^{-1}) under controlled, sterile conditions in the laboratory (light, 34°C) and in a pot experiment (15 seeds pot^{-1}) in the greenhouse. Both tests were duplicated, resulting in a total of four tests per seed lot. After one week germination percentage was recorded for each replication in the laboratory and emergence was recorded for the pot experiment.

Results

Table 4 shows the average percentages for each test, plus the combined averages of the two experiments, summarized as viability. The results show that for Lot no.10811TAN208 over 50 per cent of seeds were not viable. In the case of lot no. 10506TAN149 that number was even as high as 97.1%.

Table 4 Average percentages of the two experiments. Viability defined as the average of both experiments.

Lot no.	Petri dish	Greenhouse pot	Viability
10811TAN208	52.5	46.7	49.6
10506TAN149	2.5	3.3	2.9

P<0.001, LSD=10.23 for viability

A very clear observation in the Petri dish experiment was the presence of mould in both replications of lot no. 10506TAN149, whereas none could be seen in 10811TAN208 (Figure 14).

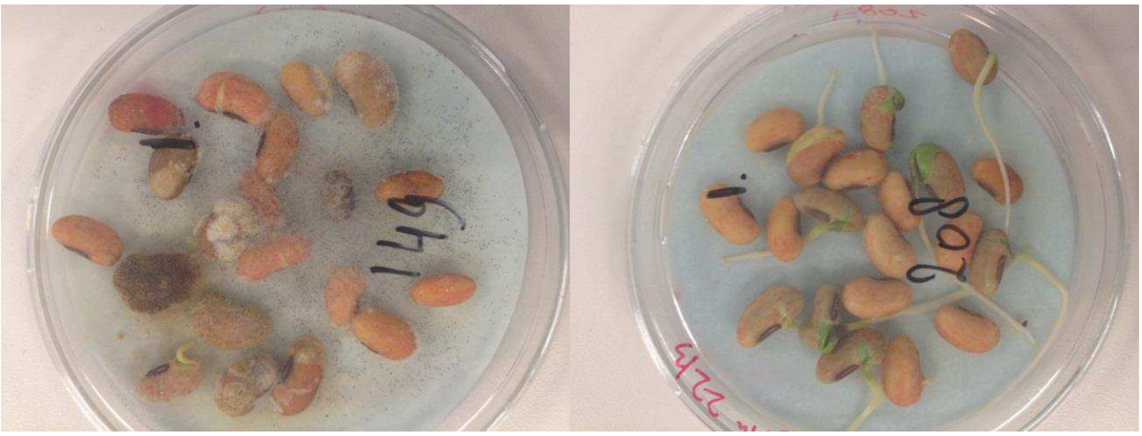

Figure 14 Germination in petri dish. On the left lot no. 10506TAN149 displayed a heavy presence of mould, whereas lot no. 10811TAN208 (on the right) did not.

Discussion

Germination percentages as indicated by certification were largely overestimated compared to those found in the laboratory (Table 5). Assuming the certified seeds were tested in a proper manner storage conditions may provide an explanation of what may have influenced these percentages to change over time.

Table 5 Differences in germination between TOSCI certification and measurements in the lab.

Seed lot no.	Certified germination (%)	Measured germination (%)	Difference
10506TAN149	88	2.5	-85.5
10811TAN208	84	52.5	-31.5

Because both replications were affected by mould in the case of lot no. 10506TAN149 and because this was not the case for lot no. 10811TAN208, it is justified to conclude that the fungus must have been seed borne. As the germination percentages found in the laboratory largely coincided with the emergence found in the greenhouse pot experiment (Figure 15) it can be assumed that the fungal presence had a detrimental effect on emergence. This be the case it is likely to have affected emergence in farmers' fields as well.

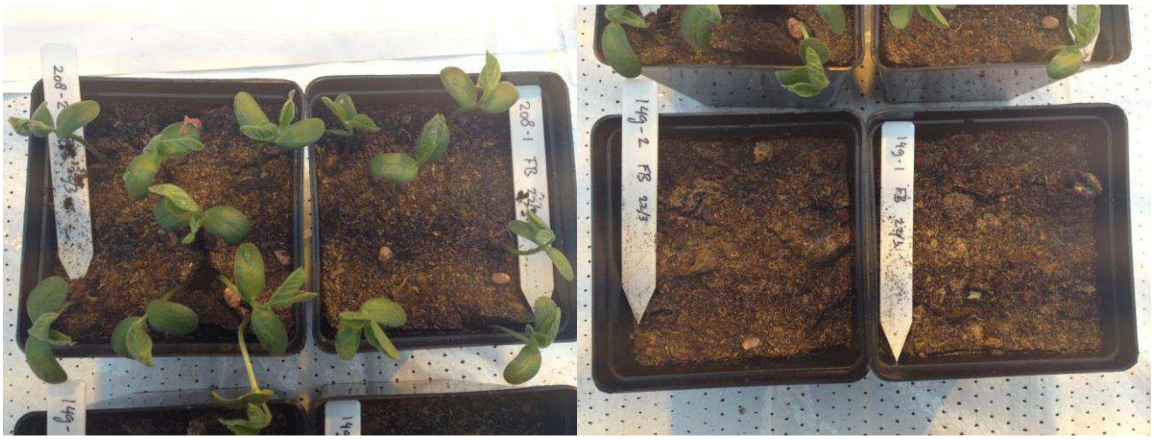

Figure 15 Result of the greenhouse experiment. On the left seed lot 10811TAN208 displayed an emergence of 46.7%. On the right only one emerged seed on lot no 10506TAN149

In any case, seed viability will likely have had an effect on crop performance in farmers' fields. Therefore it can be concluded that farmers' complaints about seed quality was just. Poorer yields may be expected for farmers who planted poor viable seeds, particularly those who planted lot no. 10506TAN149. Consequently, when measuring crop performance and yields it is advised to take into account which seed lot farmers have planted. Data on fields' plant stand and kg of seeds planted was already collected so if data on which seed lot was planted is collected presumptions on seed quality can be verified against the results of this experiment.

Lessons need to be drawn out of this experience. For a successful project it is vital for the farmers to have faith in the competence of the project staff and the products (seeds) they supply. Field observations suggest that, at least in some locations, Uyole soya-1 may be a high yielding variety (many pods per plant), possibly able to outcompete the local varieties in terms of yields. However, poor quality seeds will dismiss these positive characteristics because farmers are likely to opt for their old, trusted varieties. Ensuring high quality seeds will therefore be of key importance for the project to be successful.

Final comments

During my stay in Tanzania, after expressing some concerns, I was informally explained, by some fellow concerned colleagues within the project, that I should not be surprised if I would observe more issues with seed quality in the field: there were already some doubts about seed quality. I came to know that when the seeds were received from ASA they were supposed to be sorted by lot number, but ASA casual workers had mixed the seed lots three days before delivery. In other words, there is no way to say if lot 10506TAN149 was really 10506TAN149. It is fairly certain that at least a part of the seeds were produced in the 2011 production season, and have been sitting in store for 18 months.

My instincts say this will have a major negative impact on the farmer's attitude towards the project if similar problems arise in the second season (and, hence, on the success of the project as a whole). Already farmers were raising questions everywhere I have visited. It is absolutely critical to fix this before seed distribution for the next season, and even then a lot of work will be needed for farmers to gain back trust. I understand that N2Africa is assisting introduction of elite germplasm and seed multiplication under irrigation ready for the next season.

Chapter 6. Plant stands of soybean (*Glycine max*) in farmers' fields in the Soya Ni Pesa project in the Southern Highlands of Tanzania.

Abstract

Soybean plant stand was measured in 70 fields across Ikondo, Mambegu, Mlevela (Njombe) and Mkongotema (Songea), all part of the Soya Ni Pesa (SnP) project, which aims to increase smallholder incomes and improve soil fertility in the Southern Highlands of Tanzania. According to recommended spacing a plant stand of 444,000 plants per hectare is advised, however, farmers do not always follow recommendations. The number of plants in five 5 m × 5 m quadrats per field was counted and the average number of plants per quadrat was used to calculate field plant stand on a per hectare basis. It was found that plant stand was far less dense than the recommended spacing for all fields. Hence, in the following years there will still be a strong need to further convince farmers.

Introduction

In the four year Soya Ni Pesa (SnP) project, CRS aims to increase smallholder incomes and improve soil fertility in the Southern Highlands of Tanzania by increasing the production of soybean (*Glycine max*). SnP will target up to 11,250 farmers, who will be supported by demonstrating improved production techniques, establishment of a seed system, linking them to markets etc.

Farmers are encouraged to plants at a spacing of 0.45 m inter-row and 0.05 m intra-row (over 444,000 plants per hectare), which is stimulated by words and is demonstrated in demo plots as well. However, experiences while talking to farmers showed that farmers' attitudes toward the recommended population is that the distance between plants is far too small. It was frequently suggested that planting this close may impede plant growth. Furthermore, observations in the field showed that farmers underestimated the spacing they are planting at.

Materials and Methods

Plant stand was measured in 70 project fields across Ikondo, Mambegu, Mlevela (Njombe) and Mkongotema (Ruvuma) by counting the amount of plants in five 5 m × 5 m quadrats per field. The average number of plants per quadrat was used to calculate field plant stand on a per hectare basis.

Results

On average establishment was only 125,000 plants ha^{-1} (Figure 16). The median indicates half of the fields had a plant stand of smaller than 110000 plants per ha^{-1}. The largest number of plants per hectare (288,000) was found in Mkongotema (Songea rural), whereas the minimum, 19000 plants ha^{-1} was found in Mlevela.

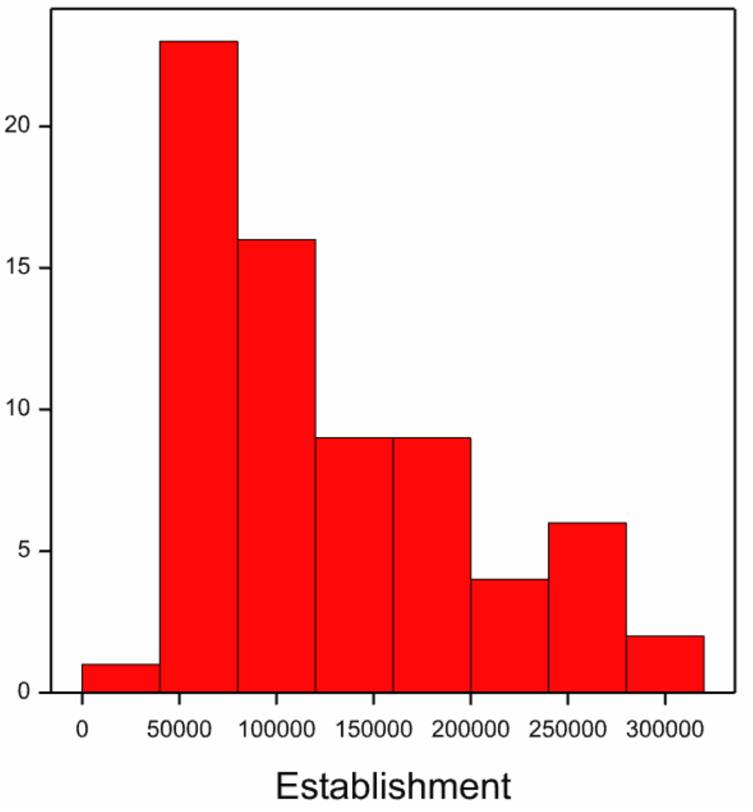

Figure 16 frequency distribution of soybean plant stand density in four villages in the SnP project (plants per hectare).

The boxplots in Figure 17 show the distribution of the measurements on a per village basis. Usually farmers planted seeds in rows, but some observations also include the broadcasting of seeds. For all villages the smallest observation amounted to less than 50,000 plants per ha^{-1}. The lowest planting density was found in Mlevela, 19,000 plants ha^{-1}. In Ikondo and Mambegu even the largest recorded densities were less than 125,000 plants ha^{-1}. Although on average plant stands in Mkongotema and Mlevela were larger, with respectively 288,000 and 256,000 plants ha^{-1} here too the densest recorded plant stand was well below the recommended density of 444,000 plants ha^{-1}.

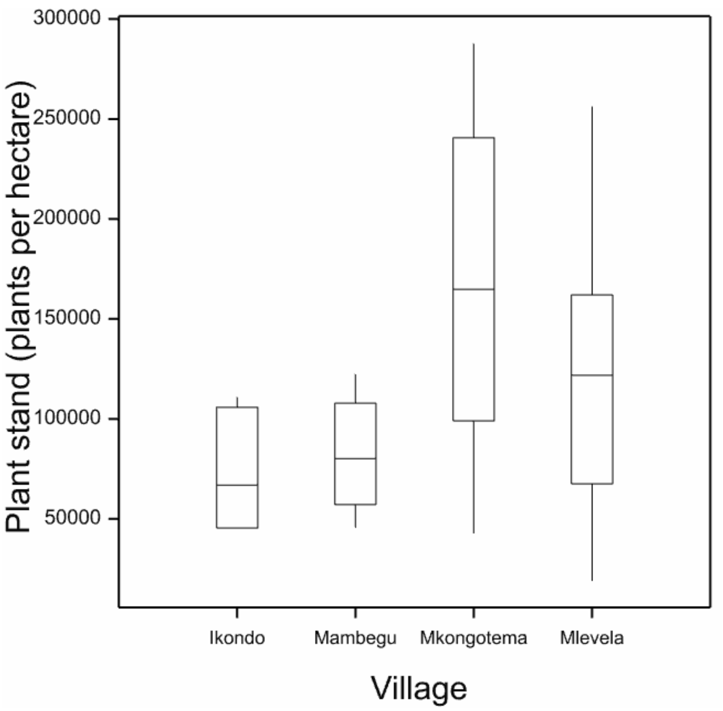

Figure 17 Distribution of soybean plant stand observations for each village.

Discussion

Clearly the achieved plant stand was very far off from what is desired in all of the measured locations. The median of 110,200 plants ha^{-1} represents a plant stand of approximately one quarter of the recommended population. Hence, in over half of all the measured fields the amount of plants would need to be quadrupled at the least to achieve recommended density. In the worst case the amount of plants would even have to be increased 23-fold. Even the largest observation of 288,000 plants ha^{-1}, measured in Mkongotema, was smaller than two thirds of the recommended population.

The germination issue described in Chapter 5 had a large impact, but does not fully explain the result. As mentioned, some discussions with famers revealed that the distance between plants in the recommended population was perceived by many farmers as far too small. In some cases we found farmers had planted in very sparse rows (>80 cm between rows) or at large distances between plants (up to 25 cm). Farmer attitude therefore was clearly also of influence.

It is interesting to witness the differences in distribution between the villages. It is difficult to explain what may have caused these. One option could be the history of soybean in the area and hence familiarity with the crop. Differences between farmers may be explained by timing of planting (amount of other activities at time of planting), workload (amount planted), farmer attitude, experience, gender, differences between field agents or other factors. Whatever the case may be, if it can be explained why some farmers are more likely to plant higher densities than their neighbours and/or how these were persuaded, a tool might be developed to better target the ones that were not.

The situation in Ikondo was slightly dissimilar to the other three villages. In here soybean is grown collectively in groups and on CEFA lands. As a result field sizes were relatively large and the number of measurements small. Furthermore, the history of soybean cropping in Ruvuma region may explain why Mkongotema shows a different distribution. In the area of Mambegu farmers also had some history of soybean growing and most farmers indicated they preferred a planting density of 50 cm × 20 cm, with 2 seeds per hole (200,000 plants hectare^{-1}). It is very interesting that the data shows that none of these farmers have achieved this desired plant stand.

Final comments

The data collected by these field measurements indicates there is still a lot of work to be done in order to have farmers adopt the technologies that are promoted within the project. Still, this is only the first year of four. My experiences while talking to farmers is that, in locations where the demo plots were well established, farmers better appreciate the recommended density by actually seeing it. In fact, several farmers indicated they intended to use the recommended planting density in the following season. Therefore I am hopeful this technology will spread in the years to come. Moreover, when farmers start planting in this way, the technology may spread to neighbouring farmers directly without the need for demo plots.

Apart from the need to convince farmers of the recommended densities, I have noticed that in many cases farmers planted at a density that 'feels right', or assume a certain distance between plants without actually measuring. This often resulted in the fact that the distances between plants were somewhat larger than they actually believe or intended. Hence, often a farmer believes the achieved plant stand approaches his or her desired density, when in reality it is certainly not. On some locations we have taken the time to visualize this by measuring and calculating the achieved density together. In all cases farmers were surprised because they had believed to have planted accurately at their desired density.

I remember one location distinctly where, after measuring, we discussed the achieved density. We calculated the amount of land needed for the same amount of plants under recommended spacing. The conclusion that this farmer's crop could have been planted in an area of only one sixth the size clearly had a major impact on his perception. He immediately acknowledged that he could save a lot of land and labour by planting closer. I think in this case the well-established demo plot in combination with making visible what this would mean for his own management turned out to be a very powerful way of convincing him.

The optimal spacing could differ depending on farmer endowment however and would be related to what factor is scarcest. In the previous example the farmer in question was limited in land and labour, but for a farmer with abundant land and labour the price of seeds may be the limiting factor. In this case it could be sensible to plant sparsely to maximise yield per plant and hence maximise returns to seed.

Finally, I do not believe that growing on communal lands in groups as done in Ikondo is an effective production method. I think collective ownership (and being paid a share of the total output) may cause a decline in productivity compared to private ownership, and in fact may even be an incentive to hold back the working effort by relying on fellow group members instead. To illustrate, after China introduced its household responsibility system as part of its reform path more than thirty years ago, the shift from collective farming to small-scale individual farming caused dramatic gains in technical efficiency with small losses in scale efficiency (Rozelle and Swinnen, 2004). A similar process could be observed in Vietnam a few years later. Many of these gains in technical efficiency are generally attributed to property rights. Of course this example is not from a location in the same region, but I believe it to be a fundamental issue, related to human nature. Moreover, while visiting some fields in Ikondo we observed most fields had not been weeded. When questioning the status of the fields several farmers indicated they had been prioritizing the crops in their private fields first.

Chapter 7. Characteristics of farmers in the villages of Ikondo and Nyave in Njombe region in the Southern Highlands of Tanzania.

Abstract

Within N2Africa a baseline survey is used to characterise the socio-economic situation of farm households. The information collected enables the identification of socio-ecological niches based on which the appropriate legume/rhizobium combination can be identified for a given type of farm. Matching a legume genotype with the right socio-ecological niche is necessary for high productivity, improved yield and enhanced farmer income. The villages of Ikondo and Nyave are targeted by the SnP project. Fields and farmers were visited, which has resulted in the set of characteristics presented in this report. Finally the survey as a tool is briefly discussed in the end of this paper.

Introduction

N2Africa is a large scale research and development project focused on putting nitrogen fixation to work for smallholder farmers growing legume crops. The project works in 13 countries in Africa: Ghana, Nigeria, DRC, Rwanda, Kenya, Malawi, Zimbabwe and Mozambique in the original project with an extension of the project in Sierra Leone, Liberia, Ethiopia, Uganda and Tanzania in 2011/2012. In Tanzania a direct link was established with the CRS project 'Soya ni Pesa' (SnP), which started at the end of 2012 in the Southern Highlands of Tanzania. SnP aims to increase the production of soybean (*Glycine max*) in order to raise incomes of up to 11,250 smallholder farmers.

Within N2Africa a baseline survey is used to rapidly characterise the socio-economic situation of farm households, and to evaluate current legume management practices. This information is also necessary to assess the project's impact over several years' time. Because the action sites for project intervention have been classified according to agro-ecological potential and in terms of market access, the baseline survey enables the identification of the socio-ecological niches that are used to identify the legume/rhizobium combination that is appropriate for a given type of farm. Matching a legume genotype with the right socio-ecological niche is necessary for high productivity, improved yield and enhanced farmer income (Ojiem et al., 2007).

According to the SnP action plan a baseline survey was intended to take place in the project's mandate areas during the first weeks of February. When the survey was delayed it was decided to gather and record as much information as possible while staying with the SnP field extension worker in the village of Ikondo, Njombe district. Fields and farmers were visited in the villages of Ikondo and Nyave and farmers, officials and development workers were interviewed.

Materials and Methods

Site description

The villages of Ikondo and Nyave are targeted by the SnP project and supported by the same field extension worker. Ikondo, the largest village of the kata (ward), houses a total of 4011 people in 618 households, whereas Nyave houses 1026 people in 178 households (2010 census). Figure 16 provides an overview of the basic layout of the kata. Ikondo consists of seven neighbourhoods, whereas in Nyave households are more or less scattered along a long-stretched road crossing over the hills.

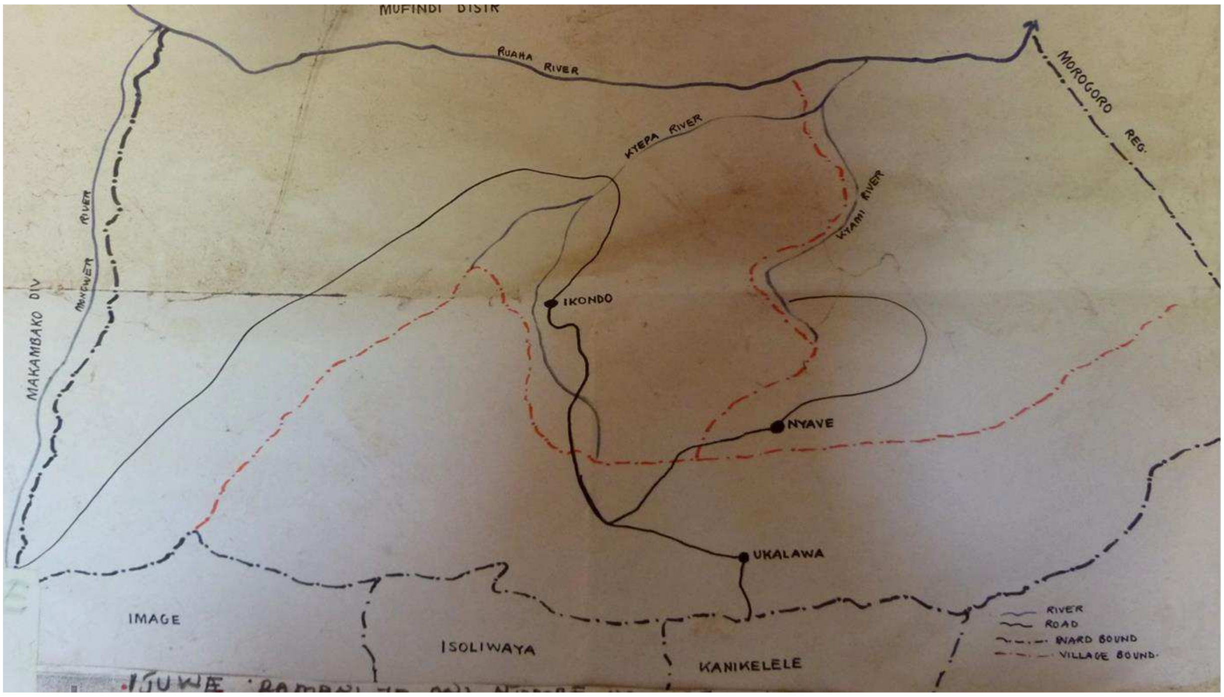

Figure 18 Map of the kata of Ikondo (Photo taken at the village office of Ikondo).

Selecting households

When selecting households, there is a risk that the choice of households is biased towards better-off farmers. Nevertheless, because of a lack of demographic information it was difficult to prevent. Based on observations it was hypothesised that farmers, part of the same socio-ecological niche, tended to cluster in the same neighbourhood. Therefore it was aimed to map the characteristics of at least five households in each neighbourhood. Part of the farmers spoken to were selected from the list of participants in the SnP projects, but the goal was to also include farmers that dropped out of the project at an earlier stage. Furthermore, the village executive officer of Ikondo was able to provide some names farmers in neighbourhoods that were not yet included in the SnP project. This has resulted in a complete dataset of characteristics of a total of 39 households, with a minimum of three households from each of the neighbourhoods in Ikondo.

Data collection

Data was collected in accordance with a baseline survey used in N2Africa (Appendix I), which focuses on the key indicators for the project. The information gathered can be divided into topics:

A. Demographic information:
B. Income: source of income, importance of farming, wealth indicators
C. Labour: hiring of labour, for which crops, cost
D. Livestock ownership
E. Land use
F. Crop production: cultivation of legumes and to a lesser extent of other crops
G. Legume utilization and nutrition: consumption in general and of legumes, used of haulms

Results

A. Demographic information

On average, 5.41 persons lived in a household. Children make up a large part of the population, as 55% of the household members were younger than 16 years old. Most of the households' heads are male, 92%.

All the households were members of a community organisation: CEFA, an Italian NGO, has been present in the village of Ikondo for decades and has a dominant impact on the villages in the area. They are involved in projects aimed at sustainable development in rural areas, particular aimed at agriculture, livestock (milk), energy, water and social participation, education and hygiene. 13% of the households indicated an additional affiliation, targeting farming activities, finances, orphan education or water.

In 69% of the households primary school was the highest schooling level completed in the household. Secondary school accounted for 28% of the answers. The remaining three per cent indicated they had completed college.

B. Income

A total of 87% of the households indicated cropping was the primary source of income, followed by off-farm labour (10%). The largest secondary source of income was livestock keeping (41%), although a larger proportion of the households, 46%, indicated they did not have a secondary source of income at all.

Farming was the dominant source of cash income (Table 6). In 62% of the cases all cash income was generated on the farm, followed by the category of most income generated from farming (21%). Only three per cent of the households indicated all cash income came from off-farm sources. About half-half and more income generated from off-farm activities accounted for 5% and 10% respectively.

Two categories most mentioned as an income generating activity outside farming were construction/carpentry and working for the government (teaching, army, health service, extension work), each accounting for 27% of the cases. Cooking and alcohol production both generated an income in 14% of the cases. Finally, a job at CEFA (9%), renting out oxen (5%) and clothes repairing (5%) were also indicated.

Table 6 Portions of cash income in the household coming from farm activities and from off-farm sources.

Class	All income from Farming	Three-quarter from farming	Half from farming, half from off-farm	Three-quarter from off farm	All income from off-farm
% of households	61.5	20.5	5.1	10.3	2.6

Table 7 provides a list of what items were indicated to be the two most expensive goods in the household. The two most indicated possessions were a radio (43.6%) and a bicycle (25.6%). Three households indicated they only owned basic needs, two indicated a piece of furniture as primary item and one indicated a cooking pot. Clustered these households form 15.4% of the respondents, which could be considered to the fraction of households with the smallest amount of resources.

Table 7 List of possessions indicated to be the most expensive goods in the household and the number of respondents who indicated these as the primary or secondary item (n=39).

Item	Primary	Secondary	Total	% of households
Alcohol drum	2	0	2	5.1
Bicycle	5	5	10	25.6
Bucket	0	1	1	2.6
Car	0	1	1	2.6
Computer	2	0	2	5.1
Cooking pot	1	0	1	2.6
Engine	1	0	1	2.6
Furniture (table, chair)	2	2	4	10.3
Milling machine	1	0	1	2.6
Motorcycle	3	1	4	10.3
Phone	1	10	11	28.2
Radio	12	5	17	43.6
Satellite dish	1	0	1	2.6
Saw	0	1	1	2.6
Sewing machine	1	0	1	2.6
TV	4	3	7	17.9
Typing machine	0	1	1	2.6
Only basic needs	3	9	-	7.7

C. Labour

28% of the interviewed households indicated family members worked on other people's land for cash or food. Conversely, 74% of the interviewed households indicated to hire labour for crop production or processing. Hired labour was applied in beans, finger millet, maize, tea, sunflower and in tree plantations (Table 8). None of the households had grown soybean in the previous season.

Table 8 Percentage of times hired labour is allocated to a specific crop (n=29).

Crop	%
Beans	79.3
Finger millet	3.4
Maize	79.3
Tea	3.4
Tree plantation	6.9
Sunflower	6.9

D. Livestock ownership

97% of the households owned livestock. None of the households took care of other people's livestock. Most households owned chicken (Table 9). Goats and pigs were popular large livestock species. Only few farmers owned cows or oxen. The average number of chicken and guinea pigs is high, partly related to a few farmers who owned up to 60 chickens or 50 guinea pigs.

Table 9 Ownership of different livestock types and the average number of each type of aminals owned per household.

Type	% households	Average number
Cattle	2.6	3.0
Dairy cows	2.6	3.0
Oxen	7.7	3.0
Goats	30.8	4.8
Pigs	41.0	3.3
Chicken	87.2	14.2
Guinea pigs	23.1	19.2
Beehives	5.1	2.0

E. Land use

On average households had 2.85 ha available for arable farming (Figure 19). The available land varied between 0.8 ha and 8 ha with over 74% of farmers cultivating between one and four hectares. These areas are based on farmers' estimates as actual field sizes were not measured.

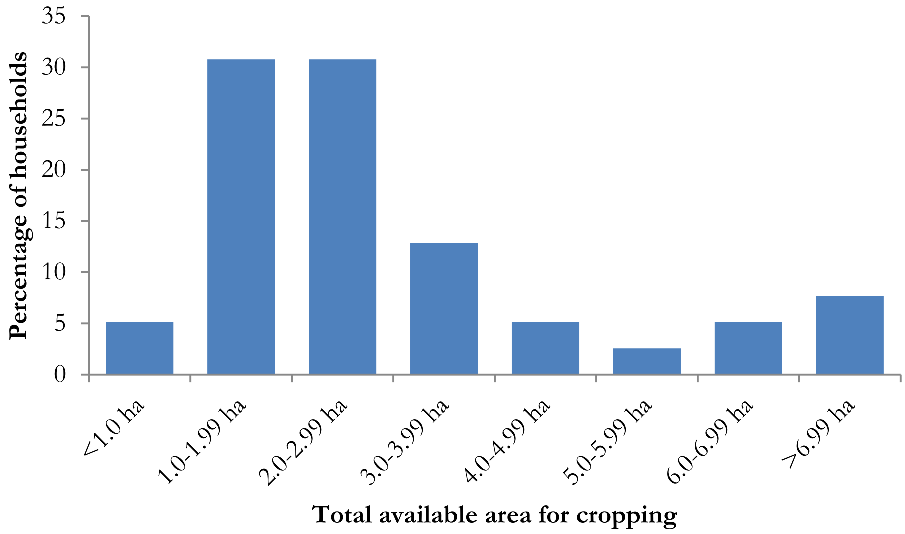

Figure 19 Distribution of land available to households for farming (% of households within a given category of landholding size).

Two out of three households indicated they left land fallow during the cropping season. The vast majority of farmers that left land fallow, 73.1%, usually did so for one year (Table 10), although almost a quarter indicated not to cultivate their land two years.

Table 10 The number of years land is left fallow.

years	%
1	73.1
2	23.1
3	0.0
4	3.8

Maize and beans were typically the dominant crops in all farming systems (Table 11). Almost 85% of the households solely included a combination of the two in their rotation scheme.

Table 11 Crop rotation schemes. Start of rotation indicated to be the first season after fallow.

Crop	1st crop	2nd crop	3rd crop	4th crop
Beans	51.3	41	2.6	0
Chickpea	0	0	0	2.6
Groundnut	2.6	0	2.6	0
Maize	41	51.3	2.6	0
Onion	0		2.6	0
Sunflower	0	2.6	5.1	0
Wheat	0	0	0	2.6
None[a]	0	5.1	84.6	94.9
Hired land[b]	5.1	0	0	0

[a]No rotation of no 3^{rd} or 4^{th} crop included in the rotation scheme
[b]Farmers that indicated to hire new land each year and hence do not use a rotation.

A third of all farmers indicated not to own any land with plantation trees (Figure 20**Error! Reference source not found.**). Over half of all households owned less than one hectare. The largest area with plantation trees was equal to 2.4 hectares. Only 7.7% of all households had access to a pasture or common grounds for grazing and 38.5% had access to wood lots or forest lands.

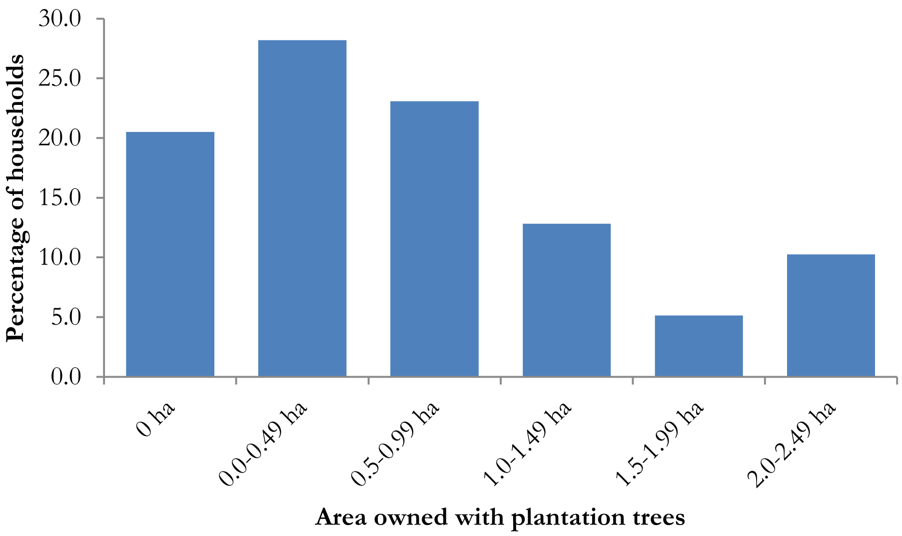

Figure 20 Amount of land owned with plantation trees (% of households within a given category).

F. Crop production

As could already be observed in Table 11 crop production is mostly limited to maize and beans (Table 12), although about one fifth of the households were also growing sunflower in at least a small part of their fields. As can be seen in Figure 21 the amount of land sown with sunflower was always less than one hectare, and even smaller than half an hectare in 62,5% of all cases, whereas areas of maize and bean both went up to over 2,5 hectares. The average areas planted to each crop were 0.98 ha in the case of maize, 1.0 ha for bean and 0.4ha for sunflower. All fields were planted in monoculture. It can be concluded that bean was virtually the only legume that is grown in the two villages, by almost all farmers.

Table 12 Percentage of households growing a specific crop (2013 season).

Crop	%
Beans	97.44
Finger Millet	5.13
Maize	100.00
Potato	2.56
Sunflower	20.51

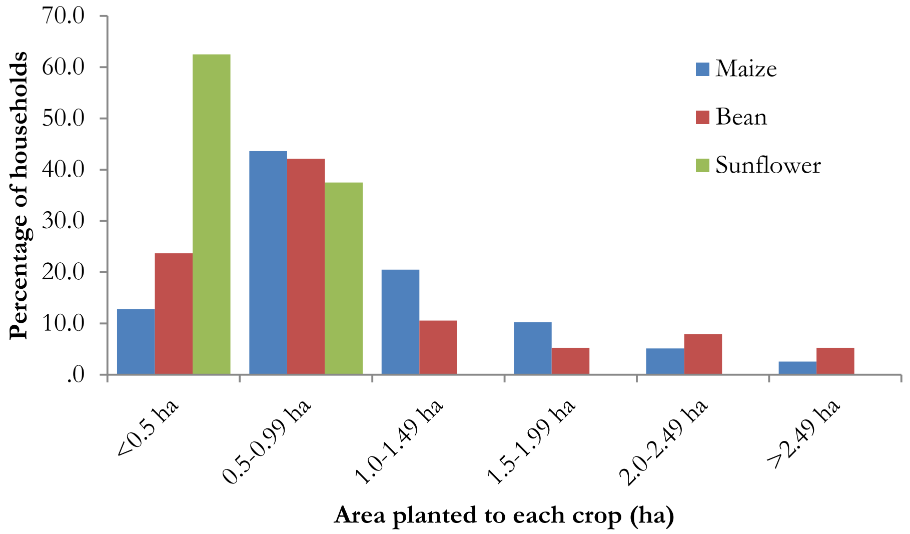

Figure 21 Area of land planted to maize, bean and sunflower (% of households within a given category).

Table 13 provides an overview of the varieties of maize, bean and sunflower grown in the villages of Ikondo and Nyave, and the percentage of households that indicated they were growing these varieties. As can be seen 43.6% of all households grew the local variety of maize on at least part of their land. In the case of beans only 7.9% of all farmers indicated they were growing a local variety. Most farmers were growing the variety called 'Soya', which actually consists of two cultivars: 'Soya ndefu' (tall/semi- climbing) and 'Soya fupi' (short/bush). Unfortunately these could not be distinguished at the time of data collection. Finally, three out of four sunflower farmers were growing Black Record, a variety recommended by CEFA.

Table 13 The varieties of maize, bean and sunflower grown in the villages of Ikondo and Nyave, and the percentage of households growing them.

Variety	%
Maize	
DK8053	2.6
Hybrid (not specified)	23.1
Local	43.6
Pannar691	7.7
UH628	2.6
UH6303	23.1
Bean	
Kigoma	13.2
Local	7.9
Msusu	2.6
Muhanga	18.4
Rosekoko	5.3
Salundi	31.6
Sewolo	13.2
Soya	78.9
Sunflower	
Black Record	75.0
Local	25.0

Many farmers used some form of organic inputs for the cultivation of their crops, usually by incorporating the remains of the previous cropping season (Table 14). Only few farmers used mineral fertiliser (DAP) in maize or beans.

Table 14 The use of organic and mineral fertilisers in maize, bean and sunflower (% of households using).

Input type	Maize	Bean	Sunflower	Average
Farmyard manure	10.3	2.6	0.0	4.3
Incorporate remains	51.3	26.3	75.0	50.9
Slash/Burn	35.9	60.5	25.0	40.5
Mineral fertilizer	2.6[a]	2.6[a]	0.0	0.0

[a]All farmers indicated they used DAP

In approximately two out of three families both husband and wife took care of the crops (Table 15). No differences could be distinguished between Maize and beans.

Table 15 Crop management (% of who is taking care in the household).

Manager	Maize	Bean	Sunflower	Average
Both	64.1	63.2	75.0	67.4
Husband	25.6	23.7	12.5	20.6
Wife	10.3	13.2	12.5	12.0

G. Nutrition

Of all households 85% indicated they had grown legumes in the previous season (all beans). On average about one quarter (25.2%) was kept for seeds or consumed within the household. In the majority of cases, leftovers in the field were incorporated in the next season (39.5%), burned

(28.9%) or a combination of the two (2.6%) (Table 16). Sometimes haulms were used as feed for livestock (15.8%). Finally, 10.5% of the households indicated remains were simply left in the field, usually related to the fact that land was hired for one year.

Table 16 Use of legume haulms (% of haulms used for a given purpose).

Haulm use	%
Burn	28.9
Feed	15.8
Home garden	2.6
Incorporate next year	39.5
Leave in field	10.5
Partly burn, partly Incorporate	2.6

Table 17 provides a list of items that were indicated to be the most important foods consumed in the household. Beans and mboga (leaf vegetable) were very popular ingredients, usually eaten as a side dish with maize (Ugali). Meat was mentioned by 59% of the households. Other popular non-legume food items include banana, cassava, potato and rice. 5% of the households indicated food shortage was a problem once every so many years.

Table 17 Most important foods in household nutrition.

Item	%
Avocado	5.1
Banana	76.9
Beans	94.9
Cabbage	2.6
Cassava	46.2
Egg	2.6
Finger millet	2.6
Fruit	7.7
Maize	100.0
Mboga (Leaf vegetable)	79.5
Meat	59.0
Pineapple	2.6
Potato	33.3
Rice	53.8
Tomato	2.6
Yams	2.6

Discussion

Sampling should always be done randomly but as mentioned in materials and methods because of a lack of demographic information it was difficult to prevent bias. By collecting the characteristics of at least five households in each neighbourhood, and including both participants and non-participants of the SnP project it was aimed to minimize this bias. Nevertheless, given that the method of data collection some bias will always be inevitable.

No GPS data of homesteads were collected, because there was no GPS available. Field sizes were also not physically measured. It is likely that in some cases farmers may not have been able to accurately estimate the exact size of their fields or simply did not know the exact size of their fields. Furthermore, sometimes it was observed that farmers did not include hired land when they were asked how much land was available for cropping. In these cases, after discussing the areas allocated to crops it would become clear more land was being used that originally indicated as being available. Finally, in addition, for various reasons farmers may also just note willing to accurately share size of their fields. Follow-up studies such as a more detailed farm characterisation could provide more reliable information and make up for some weaknesses caused by the way this data was collected.

Final comments

The data collected in the N2Africa baseline survey provides a powerful tool to identify farm types and categorise farmers based on resource endowments. While talking to farmers it became very apparent that wealth can be a major influence on what choices are made and how a farm is managed. A general impression for instance was that better off farmers tend to be able to hire more labour and cultivate a larger variety of crops than farmers with little resources. An even more obvious observation would be that poor farmers that only have a very small area available for cropping simply do not fallow because with not cropping a shortage of food would be imminent.

A more thorough classification of farmers in the whole SnP project could result in a rich database of information that may help to categorise the farmers targeted in the project. In turn a custom approach could be developed to better target each category and promote the appropriate technologies. Finally, all the collected data could help assessing the impact of technologies towards the end of the project.

Chapter 8. Challenges and opportunities

- Currently a lot of maize and bean production takes place in the target areas. Maize is clearly the number one crop and judging from farmers opinions it seems unlikely that it will be replaced. At this moment soybean is therefore more likely to compete with bean and sunflower. The price difference between bean and soybean, yields and cost of production, will be important factors for farmers in their decision to cultivate either crop. Furthermore, bean is also an important food crop for household consumption.

Market

- The potential risk should be small enough or the potential profits large enough for farmers to venture into soybean production. With the history of failing markets, market linking will be essential for farmers' trust and the market for soybean would need likely to be larger than the one for beans. Hence, the marketing side of the project will have a major impact on the response of farmers for the next year.

- The price of bean in Ikondo and Nyave is usually between 15.000 and 22.000 TZSH per debe (1 debe = 20 kg). Because of difficulties of transporting their harvest themselves, farmers are at the mercy of middlemen who tend to buy at low prices (or buy pre-harvest at an even lower price) and make large profits by selling in the city. Farmer income would greatly benefit from cutting out these middlemen.

Storage

- The price of beans tends to increase with time after harvest. Therefore initial storage before marketing the produce could be an opportunity for increasing profitability. CEFA indicated they would be interested in starting cooperatives for this purpose in Ikondo, but they will be backing out of Ikondo by the end of 2013 and are therefore focussed on sustainability of the current projects.

Inoculants

- The workshop about inoculants provided lots of valuable information, but it seems not all of the information reached its audience. Some basic knowledge about the product and how to handle it is vital when supporting local farmers. A rethink on how to ensure effective communication.

- Distribution in 2.5 kg bags comes with contamination risk related to the further dividing into smaller portions that are distributed to farmers. Small sterile packages of for instance 40 g could instantly solve the sterility concerns related to the distribution.

Demo plots

- Demo plots are clearly a strong tool to visualise proposed management and to convince farmers, but only if they are set up properly. There is an absolute need of a better understanding and higher sense of conviction to set all of them properly next time. This may also improve FEO efficiency in convincing and supporting local farmers, as they will be backed up with visual evidence to support their claims. A Minjingu rock phosphate treatment with and without the combination with inoculation still provides opportunities to further explore local management options.

Field measurements

- Fields measurements have been a drama but can be improved easily. There are powerful gps tools that allow very accurate area measurements, just by walking around a field. A gps tool was supplied in fact, but in the form of a usb-stick. This is not practical because it demands to be used in combination with a laptop that would have to be carried around the field. A tool in the form of a pda could likely solve all field measurement problems. Not only would the collected data be more reliable, collecting it can be done in a fraction of the time that is currently spent on it. This would be especially interesting with the number of fields in the project increasing substantially in the next seasons.

Transport

- The FEOs cannot be expected to travel over 40 km a day and do a good job if they are not provided with some reliable availability of a mode of transport. The continuously returning problem of arranging and waiting for a motorcycle is clearly a burden and reduces motivation. FEO approach toward the issue is worrisome however. A more proactive attitude needs to be stimulated.

FEOs

- FEOs were supplied with the tools and information to support them in their tasks and they receive a lot of freedom to fill in their jobs. However, it seems a higher awareness of what is expected is still needed. Lembris' work corrected many of the issues not addressed or observed by FEOs, but this will become infeasible as the project expands. Therefore there is an absolute need for improvement. Possibly their job needs a stricter form of protocol.

For instance, supply them with a modem and demand a weekly status update and schedule.

- Most data that is collected is still provided in hard copy, where in fact all FEOs were supplied with a brand new computer. They did not get a computer to play games (during a meeting!) and it is justified to demand the supplied software and tools to be used, and reporting to be shared digitally. This would also greatly improve Lembris' work. Visiting villages to chase every FEO for their data, checking the validity and hiring farmer volunteers will become unfeasible with more than the current 300 farmers.

- Administrative capacity and work ethics are of far higher importance than for instance a degree in agriculture. Some relevant knowledge can be picked up in the field, and issues such as disease can easily be addressed by communicating with or sending in an agricultural expert from elsewhere in the project. The volunteers in Ruvuma essentially did a better job in collecting field data than their (educated) FEOs, i.e. hire motivated and innovative people, rather than people with a degree.

- It is striking that a farmer volunteer in Ruvuma was able to extensively document 27 locations/households in a matter of a week, whereas a full-time FEO was unable to do this in a far longer timeframe. The lack of interest in fieldwork is concerning. The impression is that the FEOs expected to become manager and have trouble coping with the realities of an everyday job. There is an absolute need to improve and support their work ethics.

Office location

- The main activities take place in the Southern Highlands, but CRS office is located in Dar es Salaam. A lot of costs are involved in flying and driving back and forth. It would make more sense to have an office location in Songea for instance, the region where most farmers are located. This would also improve communication with the local partner organizations.

Costs and returns

- Collection of data on costs of labour, inputs etc. and comparing different management options can result in an accurate set of tools to provide different farmers with different endowments with a custom advice.

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Appendices

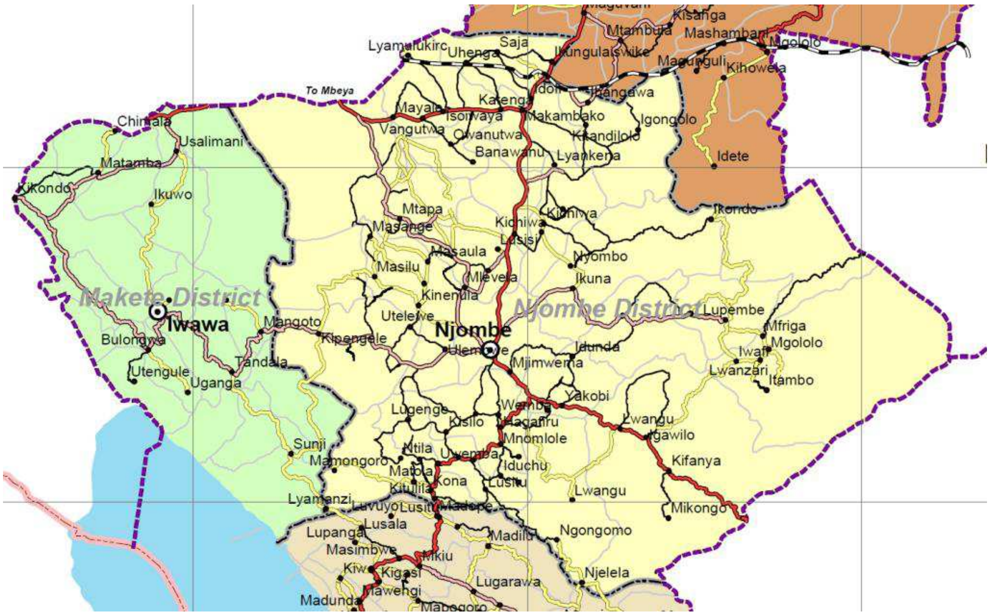

Figure 22 Road map of Njombe.

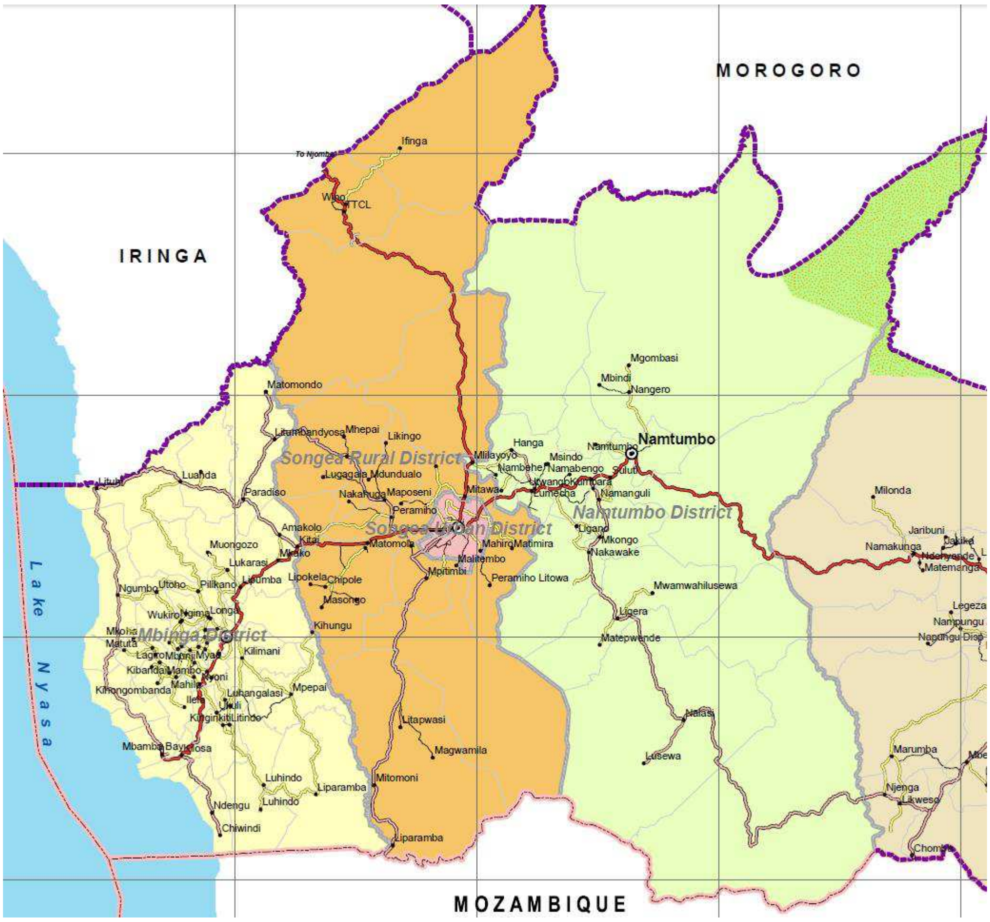

Figure 23 Road map of Songea.

Analysis of variance

Variate: Average_nodule_score

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Location stratum	5	21.1570	4.2314	5.08	
Location.*Units* stratum					
Spacing	1	0.8578	0.8578	1.03	0.317
treatment	3	20.8488	6.9496	8.34	<.001
Spacing.treatment	3	2.9761	0.9920	1.19	0.327
Residual	35	29.1636	0.8332		
Total	47	75.0033			

Tables of means

Variate: Average_nodule_score

Grand mean 1.23

Spacing	Farmer	Recommended
	1.36	1.10

treatment	0	DAP	DAP+I	I
	0.25	1.03	1.95	1.69

Spacing	treatment	0	DAP	DAP+I	I
Farmer		0.33	0.78	2.35	2.00
Recommended		0.17	1.28	1.56	1.39

Standard errors of differences of means

Table	Spacing	treatment	Spacing treatment
rep.	24	12	6
d.f.	35	35	35
s.e.d.	0.264	0.373	0.527

Analysis of variance

Variate: Germination_percentage

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Method stratum	1	12.50	12.50	0.39	
Method.*Units* stratum					
Lot_no	1	4355.56	4355.56	137.54	<.001
Residual	5	158.33	31.67		
Total	7	4526.39			

Tables of means

Variate: Germination_percentage

Grand mean 26.2

Lot_no	149	208
	2.9	49.6

Standard errors of differences of means

Table	Lot_no
rep.	4
d.f.	5
s.e.d.	3.98

Least significant differences of means (5% level)

Table	Lot_no
rep.	4
d.f.	5
l.s.d.	10.23

N2Africa Baseline Survey

Date of interview: _____/______/2012

Country: ___________________

Enumerator: ________________________

Action site (District/County/…): __________________

Village: _____________________

Homestead coordinates (decimal degrees)

Latitude: _____________ Longitude:______________ Altitude: _____________

Introduction

Introduce yourself and the N2Africa project. Explain the purpose of the survey and assure the interviewee of the confidentiality. Please check if the farmer has any questions at this time.

A. Demographic information

A.1.Name of respondent: _________________________________

A.2. Total number of adults and children in the household

Adults: _________ Children (16 years or younger):__________

A.3. Gender of the household head: Male____ / Female____

A.3. Is anyone in your household affiliated to a community organisation? Yes/ No

If yes, please fill the table below:

Name of the organisation	Purpose/objective of the organisation
1.	
2.	
3.	

A.4. What is the highest schooling level completed by a person in the household (tick)?

1. Primary: ________ 2. Secondary:_________

3. Post-secondary: __________ 4. College / University:__________

5. Informal / other:__________ 6. None:_______

B. Income

B.1. What is the most important source of household income (please tick):

1) Cropping _____ 2) Livestock ____ 3) Trade ____

4) Off-farm income ____ 5) Remittances ____

6) Other (specify): _________________________

B.2. Can you estimate the portion of the cash income in your household coming from farm activities and from off-farm sources? Choose what best describes your situation:

	Tick
1) All income from farming	
2) Most from farming, a small part from off-farm sources	
3) About half-half from farming and off-farm	
4) More from off-farm sources and less from farming	
5) No Income from farming, all from off-farm sources	

B.3. Please specify any income generating activities outside farming:

____

B.4. What are the two most expensive goods in the household (e.g. radio, bicycle, car,…)?

1.___________________________ 2.___________________________

C. Labour

C.1. Do you or your family members work on other people's land for cash or food? 1) Yes______ 2) No______

C.2. Do you or your family members hire labour to work on your farm?

1) Yes ___ 2) No ___

If yes, indicate in which crops hired labour is used:

____

D. Livestock ownership

Please indicate the number of livestock owned or taken care off in the household

	Owned	Cared for, but not owned		Owned
Cattle (total)			Chicken	
Dairy cows			Guinea fowls	
Oxen			Guinea pigs	
Sheep			Rabbits	
Goats			Bees	
Donkeys			Other (specify) ______________	
Pigs				

E. Land use

E.1. Total amount of arable land available for cropping, including fallow land, but excluding plantations and grazing land (indicate ha or acres): _______________

E.2. Do you leave land fallow during the cropping season?

1) Yes:____ 2) No:______

If yes, how long is a field typically left fallow (years): _____________

E.3. Please describe one or two typical crop rotations, starting for instance when land has been cleared / burned for planting after a fallow period

Rotation 1

	Principle crop	Second crop	Third crop
Season 1			
Season 2			
Season 3			
Season 4			

Rotation 2

	Principle crop	Second crop	Third crop
Season 1			
Season 2			
Season 3			
Season 4			

E.4. How much land do you own with plantation trees (indicate ha or acres)? _______________

E.5. Do you have access to pastures for grazing? 1) Yes____ 2) No____

E.6. Do you have access to wood lots / forest land? 1) Yes_____ 2) No____

F. Crop production

Please fill the table below for the main arable and plantation crops grown on the farm (exclude small vegetable gardens etc.)

Crop	Area with this crop (ha or acres)	Variety	Animal manure applied (Yes/No)?	Other organic input applied? If yes, specify type	Mineral fertiliser applied? If yes, specify type	Who manages the crop (wife, husband, both husband and wive, other)?
Cowpea						
Groundnut						
Soybean						
Other legume (specify) __________						
Cassava						
Rice						
Banana						
Rubber						
Palm oil						
Maize						
Other non-legume crop (specify) __________						
Other non-legume crop (specify) __________						

G. Legume Utilisation& Nutrition

G.1. Use of legume grain

How do you use legume grain?

Type of legume	Total production in the most recent season (kg)	Amount used in the household for consumption / seed (kg)	Amount used for sale (kg)
1			
2			
3			
4			
5			

G.2.Use of legume haulms

How do you use legume haulms (E.g. as feed for own livestock, sale to other people, incorporation in the soil at planting, burned in the field, etc.)

Type of legume	How are the haulms used?
1	
2	
3	
4	
5	

G.3. Nutrition

What are the most important food items consumed in your household?

1.	4.
2.	5.
3.	6.

Is food availability in the household ever <u>not</u> sufficient to satisfy demand of all members? Yes/No

Please, thank the respondent for her/his time. Check if the farmer has any questions at this time.

ATTACHMENT E
PERFORMANCE INDICATORS

Activity	Indicator	Target for 2013	Target for 2014	Target for 2015	Target for 2016
Demonstrate Improved Egg Production Techniques	Number of chicken coop demonstrations established	25	45	30	0
	Number of chicken production units formed	625	1,125	750	0
	Number of field agents trained in best practices for egg production	10	18	12	0
	Number of individual chicken coops built	625	1,025	750	0
	Number of women trained through demonstration chicken coops	650	1070	780	
Demonstrate Improved Soybean Production Techniques	Number of farmers who receive training through demonstration plots	2,250	4,500	4,500	0
	Number of soybean demonstration plots established	30	60	60	0
Establish Soybean Seed System	Number of farmers trained in quality seed production	2,250	4,500	4,500	0
	Number of partial value coupons distributed to farmers	1,500	3,000	3,000	0
	Volume (KG) of certified seed procured for seed production	10,000	20,000	30,000	0
	Volume (KG) of seed produced by farmers for subsequent season	100,000	200,000	300,000	300,000
Facilitate Access to Storage Facilities	Number of storage facilities renovated	45	90	90	0
	Percent of farmers groups accessing storage	50	50	50	50
	Volume (MT) of storage space made available	2,500	5,000	5,000	5,000
Form and Train Savings and Internal Lending Communities	Number of Community Field Agents certified as Private Service Providers	34	8	8	0
	Number of Community Field Agents trained	38	10	10	0
	Number of Producer groups formed	60	120	120	0
	Number of SILC groups formed	200	300	400	0
Link Farmers to Agro-dealer Networks	Number of agro-dealer networks identified and strengthened	4	4	4	0
	Number of farmer groups receiving services from agro-dealers	60	120	120	0
Link Farmers to Existing Financial Opportunities	Dollar value of loans facilitated	25,000	50,000	50,000	100,000
	Number of loans accessed by farmers	375	750	750	1,500
Link Farmers to	Number of farmer groups	0	60	120	120

Market Information	accessing market information				
Link Farmers to Markets	Number of associations formed	0	6	12	12
	Number of producer groups selling directly to formal buyers	0	60	120	120
	Number of producer groups using radio and/or print advertisements to market their products	0	60	120	120
	Number of written agreements between farmer groups and buyers	0	60	120	120
Train Producer Groups in Farm Management Skills	Number of farmers trained in marketing and agro-enterprise development, innovation, and sustainable production	2,250	4,500	4,500	0
	Number of producer groups trained in developing business plans	60	120	120	0
	Number of groups trained in developing natural resource management plans	60	120	120	150
	Number of groups trained in improving quality of their produce	60	120	120	150

Result	Indicator	Baseline	Final Target
Increased Agricultural Productivity	Percentage increase in volume of soybean harvested per hectare (yield) tba	TBD	30
	Number of eggs produced by target chicken production units	TBD	13,600,000
	Number of individuals benefiting directly from USDA-funded interventions	0	13,750
	Number of women benefiting directly from USDA-funded interventions	0	4,750
Increased use of Improved Agricultural Techniques and Technologies	Number of hectares under improved techniques or technologies as a result of USDA assistance	TBD	22,500
	Number of farmers and others who have applied new techniques or technologies as a result of USDA assistance	TBD	11,250
Increased Availability of Improved Inputs	Volume (MT) of soybean seed supplied to farmers	TBD	60
	Volume (MT) of soybean seed produced by farmers	TBD	600
	Number of farmers who received day-old chicks for egg production	TBD	2,500
Improved Infrastructure to Support On-Farm Production	Number of improved chicken coops built	TBD	2,500
Increased Use of Financial Services	Number of farmers and others receiving financial services as a result of USDA assistance	TBD	3,375
	Number of loans disbursed to farmers and others as a result of USDA assistance	TBD	6,800
	Value of agricultural and rural loans provided with USDA assistance	TBD	225,000

Increased Knowledge by Farmers of Improved Agricultural Techniques and Technologies	Number of farmers and others who have received training on improved agricultural techniques and technologies as a result of USDA assistance	TBD	11,250
	Number of farmers who have knowledge about improved agricultural techniques and technologies	TBD	11,250
Improved Farm Management (Operations, Financial)	Number of farmers and others who have applied improved farm management practices (i.e. governance, administration, or financial management)	TBD	11,250
Improved Knowledge Regarding Farm Management	Number of farmers and others who have received training on improved farm management practices (i.e. governance, administration, or financial management) as a result of USDA assistance	TBD	11,250
	Number of farmers demonstrating improved knowledge regarding farm management as a result of USDA assistance	TBD	9,000
Increased Access to Improved Market Information	Number of farmers who have access to at least one source of current agricultural market information	TBD	18,750
Expanded Trade of Agricultural Products (Domestic, Regional, and International)	Volume of trade (MT) in soybeans	TBD	11,000
	Volume of trade (number) in eggs	TBD	10,600,000
Improved Quality of Post Production Agricultural Products	Volume of soybeans (MT) meeting buyer standards	TBD	11,000
	Volume of eggs (number) meeting buyer standards	TBD	10,600,000
Increased Use of Improved Post Production Processing and Handling Practices	Percent of farmers that report using one or more improved post-production processing practice(s)	TBD	75
Improved Post-Harvest Infrastructure	Total increase in installed storage capacity (MT dry or cold storage) as a result of USDA assistance	TBD	750
Increased Access to Markets to Sell Agricultural Products	Number of distinct markets to which soybeans are sold	TBD	4
	Number of distinct markets to which eggs are sold	TBD	96
	Number of farmers bulking and selling produce	TBD	7,500
Improved Marketing of Agricultural Products	Percent of groups that use at least two forms of media to advertise their products (print, radio, etc.)	TBD	75
Improved Linkages Between Buyers and Sellers	Number of agreements signed (contracts, MOU, etc.) between buyers and sellers	TBD	7,500