N2Africa Podcaster no. 10

October 2011

Introduction

N2Africa has a strong focus on agronomic management to improve crop yields. We start from the premise that successful nitrogen fixation and yield of legumes in the field depends on the interaction:

$(G_L \times G_R) \times E \times M$

(Legume genotype × Rhizobium strain) × Environment × Management

where environment encompasses climate (temperature, rainfall, day length etc to encompass length of growing season) and soils (acidity, aluminum toxicity, limiting nutrients etc). Management includes aspects of agronomic management (use of inoculants, mineral fertilizers, sowing dates, plant density, weeding).

Thus establishment of effective BNF depends on optimizing all of these components together. In this Podcaster we report on recent agronomy research that has been conducted to date. We show the importance of the M factor in achieving the potential of the legume/rhizobium symbiosis for nitrogen fixation and yield.

We have been receiving strong feedback suggesting that readers of the Podcaster are pleased with the regular news. At present we are mailing directly to >500 people across many continents and countries – if you have friends who would like to receive the Podcaster please send their email addresses to N2Africa.office@wur.nl

Ken Giller

N2Africa develops best-fit agronomic practices for grain legumes in Africa

The agronomy activities of N2Africa are implemented under Objective 2 of the project *(Select multi-purpose legumes (food, fodder, stakes, and soil fertility management) for enhanced biological nitrogen fixation (BNF) and integrate these into farming systems)*. Activities focus mainly on i) identification of best varieties of soyabean, common bean, cowpea, groundnut, as well as multi-purpose tree and forage legumes with high BNF potential; and ii) developing best fit agronomic practices for maximizing potential benefits of selected legume germplasm and inoculant technologies on increasing and stabilizing productivity. Country specific priority legumes and agronomic practices identified and prioritized during project inception workshops in year 1 continue to be revised at the beginning of each planting season and modified according to outcome of activities implemented in the previous season(s) in order to accommodate new emerging issues from farmers, market demands as well as biophysical challenges including pests and diseases and drought.

Table 1. Grain legume varieties undergone evaluation for BNF potential in different countries. Rainfall in East Africa is bimodal allowing two cropping seasons each year.

Country	Soyabean	Bean	Groundnut	Cowpea	Total
Kenya	13	17	0	0	30
DR Congo	8	10	0	0	18
Rwanda	8	10	0	0	18
Nigeria	5	0	5	6	16
Ghana	6	0	6	6	18
Zimbabwe	6	6	2	1	15
Malawi	6	4	2	2	14
Mozambique	6	0	0	0	6
Total	**58**	**47**	**15**	**15**	**135**

Agronomy work to date

Trials to identify best varieties of soyabean, bean, cowpea and groundnut with high BNF potential continues in all 8 project countries. Currently, a total of 135 varieties have been evaluated at 65 action sites in the project's eight countries (Table 1). Some varieties are showing good performance across many impact zones, for example the soyabean variety TGx1740-2F (performing well in the East, Central and southern Africa) and soyabean variety TGx1904-6F (performing well in West and Southern Africa). In many ways it is surprising these varieties do so well in the highlands of East and Central Africa, and in southern Africa, given that they were selected by IITA under very different environments in Nigeria. Likewise, climbing bean varieties Gasilida and RWV 2070 appear to be suitable for both medium and higher altitude areas of East and Central Africa. Several other varieties seem to perform best under rather specific conditions. Certainly, identification of legume varieties to specific production niches will be the focus of our work in the first quarter of year 3.

The agronomy team is also working to develop best-fit legume agronomic practices in the different impact zones. So far we have established 131 trials in the N2Africa mandate areas across the 8 countries, with 89 trials evaluating the impact of inoculants and phosphorus application on legume performance (Table 2). Currently, we have complete data sets available from 112 trials, and data from the remaining 19 trials are still with partners in the different countries. The results available provide evidence of positive response of soyabean, cowpea, groundnut and bean to the application of P-based fertilisers (TSP or SSP). Response to P fertilizer was not observed in all cases

Table 2. Legume technologies tested in different countries

Country	Trial type						Total	Trials with data available
	Rhizobium inoculation/ P fertilization	Legume disease evaluation	Systems (intercropping / rotation/g)	staking climbing beans	Non-responsive soils	Mid-season drought		
Kenya	18	2	9	4	0	3	36	34
DR Congo	12	2	4	3	0	0	21	17
Rwanda	14	2	8	0	0	0	24	17
Nigeria	18	0	0	0	3	0	21	21
Ghana	8	0	2	0	0	0	10	10
Zimbabwe	8	0	0	0	0	0	8	6
Malawi	8	0	0	0	0	0	8	4
Mozambique	3	0	0	0	0	0	3	3
Total	**89**	**6**	**23**	**7**	**3**	**3**	**131**	**112**

where growth and yields were poor, implying that other factors were limiting – what have been termed the non-responsive soils. Addressing the underlying constraints in non-responsive soils, as well as the extent of other limiting factors is the current task of the agronomy team. In East and Central Africa where the agronomy work has been completed for three seasons (the fourth season on-going), adaptive research campaigns have started to address the emerging issues including: best rotation and intercropping system of cereals and grain legumes, legume diseases (soyabean rust), best staking materials and staking methods of climbing beans. In Kenya, we have started to address the problem of mid-season drought. It is expected that results from these initiatives will contribute to better-informed advocacy messages and improve targeting of our legume technologies.

Freddy Baijukya

Soyabeans responds to rhizobium inoculation in DR Congo

In South Kivu of DR Congo, on-farm trials have been ongoing for three seasons to ascertain the response of soyabean to rhizobium inoculation and phosphorus fertilizers. Trials were established in three zones of South Kivu namely the southern zone (sites Mulamba and Ikoma, Mushinga), the northern zone (sites Bughore, Karehe and Birava) and the south-east zone (sites Mumosho and Nyangezi). Testing was done with BIOFIX, a commercial rhizobium inoculant from MEA-Kenya, two P-fertilisers (DAP and TSP), K-fertiliser (muriate of potash – KCl). Small quantities of urea were used a sowing in some experiments to test the effect of a 'starter' dose of N.

In the five out of seven sites that provided yield data, we observed a yield range of 1.1 to 2.6 t/ha with an average yield of 1.5 t/ha. Inoculation with BIOFIX gave a small but consistent yield increase of between 9-10% (0.1-0.25 t/ha). BIOFIX was more effective especially where a combination of TSP and KCl were applied. It appears that in South Kivu, there is no need of using starter nitrogen if rhizobium inoculants are available. The relatively small, but consistent, soyabean yield increases caused by inoculation highlight the need for accurate yield assessments and relatively homogenous trial fields in order to observe these differences. Given the small costs associated with inoculation, also a yield increase of 9-10% make the investment in ino-culation worthwhile for farmers. Much larger yield increases have been observed in many of the numerous demonstration plots that are scattered across the landscape. Farmers have expressed interest in using BIOFIX. In addition, they would like to increase the number of trials and size of plots in the upcoming season. N2Africa has responded to this request by providing farmers with 75 kg of inoculants, enough to establish 1,500 ha of soyabean.

Photo 1: These plants are showing symptoms that are typical of magnesium deficiency: yellowing between the veins of the *young* leaves (interveinal chlorosis). The problem is more pronounced where K fertilizer is added – a well-known phenomenon due to imbalances in the availability of cations. Potassium deficiency can look rather similar but tends to be seen on the older leaves and, of course, is not seen when K fertilizer is used.

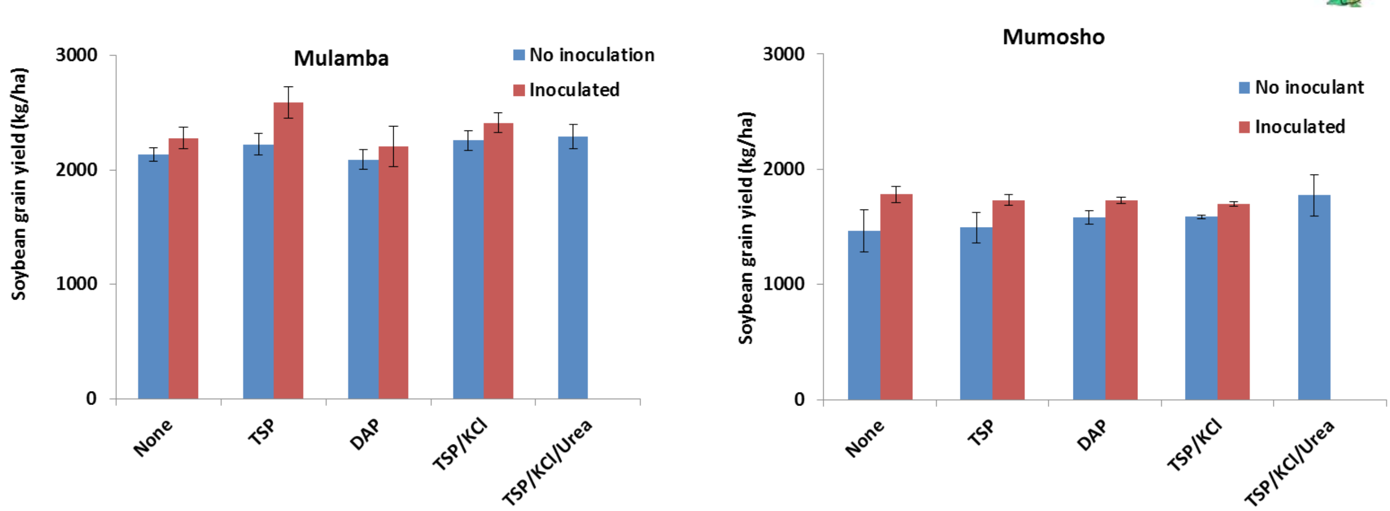

Figure 1: Response of soyabean to rhizobium inoculation and application of P, K and Urea as observed at Mulamba and Mumosho sites in DRC Congo. The trend is similar to other sites.

Generally, the trials are showing clear responses of bean and soyabean to P and K application. Especially in the southern zone, where soils are particularly depleted, other nutrient deficiencies appear to be constraints. Also in the northern zone, visual observations of plants on some soils show deficiency symptoms that are induced when K fertilizers are added. The symptoms are typical of magnesium deficiency – which can be induced by addition of K fertilizer when there is little available magnesium in the soil. The agronomy team in DR Congo is now testing a new legume fertiliser blend called SYMPAL to address the possible magnesium problem. Moreover, the team is developing a plan to investigate thoroughly the factors limiting soyabean growth. This includes studies to unlock the interactions between legume genotypes, rhizobium and management and this is a study topic of one of the N2Africa MSc students from DR Congo.

Jeanmarie Sanginga, Freddy Baijukya and Linus Franke

Adaptive research to understand bean production niches in Western Kenya

Western Kenya is densely-populated (on average 750 person/ km^2) and the area of farm land available is less than 0.1 ha per capita. The area suffers from poor crop productivity due to poor soil fertility arising from continual cultivation without inputs. Bush-type common bean (*Phaseolus vulgaris* L.) is the most important pulse crop in the system but grain yields under farmer conditions remain as small as 400 kg /ha. Because the pressure on land is so acute, increasing yield is an imperative. An important option is to introduce climbing beans. Because climbing beans growing vertically they can produce a lot of biomass and yield in the limited space for planting, and provide more yield than bush bean varieties.

Data from two seasons indicate yields of climbing bean ranged from 0.2 to 3.6 t/ha: the best yields were observed on mid-altitude areas on relatively fertile soils (soil carbon above 2%). We observed no clear impact of inoculation on climbing beans. P-based fertilizers gave clear increases on growth and yield of climbing beans on 60% of the sites,

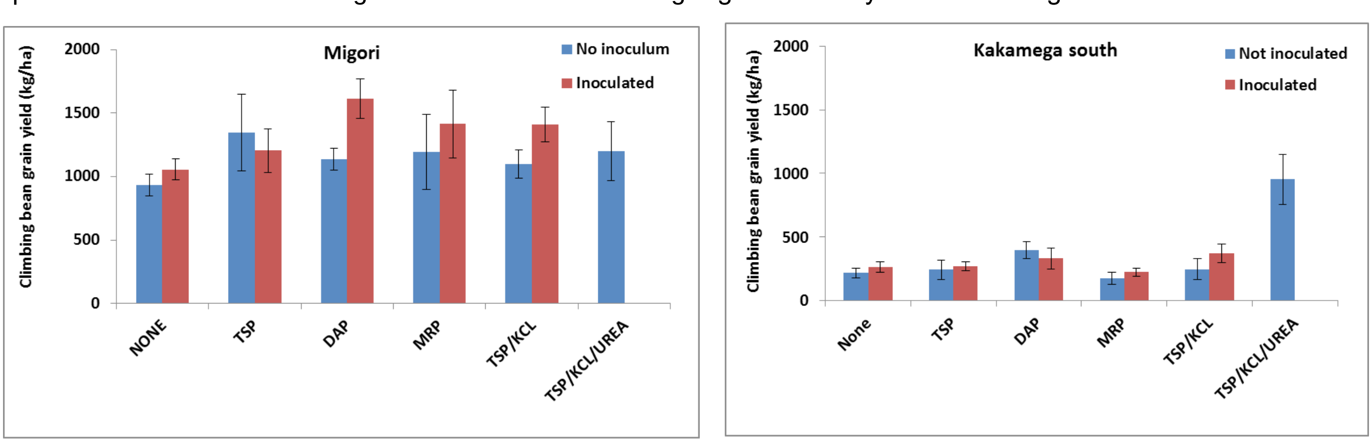

Figure 2. Response of climbing bean (variety Kenya Tamu) to different sources of P fertilizer with (+R) and without (-R) rhizobium inoculation as observed at two sites, Migori and Kamamega, in Western Kenya. Performance at Kakamega site was confounded by biotic stresses.

Good performing site in Migori, roots had many nodules

Poor performing site in Kakamega South, plants with multiple problems

Poor vigor due to damage by root rot disease

Knots on bean roots

with beans to with the yield responses varying between 2 and 30% overall. The strongest responses were obtained when P was applied in the form of DAP and/ or TSP in combination with K indicating the need potassium, and a small response starter N but this remains to be confirmed.

The observed lack of response of climbing bean inputs might, to a large extent, be attributed to a mixture of biotic stresses. On poorly-performing sites especially where beans have been frequently cultivated (e.g. Kakamega South) we observed severe damage by bean stem fly maggot and root rot (*Fusarium solani*). At a later stage bean roots had many 'knots' characteristic of massive infection with the root knot nematode (*Meloidogyne*) with few or no nodules at all. These problems could be alleviated by more frequent crop rotation. The very low P status of many soils in the area suggest that P availability will be an emerging constraint when the most pressing biotic constraints have been relieved. The focus now is to look into agronomic practices and rigorous variety selection to address these emerging biotic challenges. Nevertheless, on good soils where biotic stresses are controlled, climbing beans can provide a three-to-one yield advantage compared with bush beans.

Freddy Baijukya, John Mukalama and Wycliffe Wekesa, Linus Franke

Agronomy trials in Zimbabwe: results achieved and the way forward

The agronomy trials in the 2010-2011 season in Zimbabwe did not run quite as anticipated, but nevertheless yielded interesting results. The results led to a change in planning and responsibility for the next season, as well as additional research activities.

Of the 33 trials originally planned for the 2010-2011 growing season, 23 trials were eventually established and only 10 gave yield data. Over-ambitious planning and a failed partnership caused this large difference between the plan and the actual achievements. Yield data were collected from one bean, two cowpea, two groundnut and five soyabean trials. Five of these trials (including all groundnut trials) were located in a particular region of Murewa, a few km apart from each other. As an example, we give results from a soyabean input in Murewa, Kadadi field.

Results from a soyabean input trial in Murewa

Yields achieved in this trial were overall rather poor. The field used was a sandy outfield with a poor soil structure and low fertility status. The very sandy soil texture, a low pH, and low C and N concentrations in the soil indicate that soil conditions were far from ideal for growing soyabean (Table 3). In addition, rainfall distribution was very poor throughout the season. Nevertheless soyabean grain and stover yields showed very strong responses to application

Table 3. Soil characteristics in the trial in Murewa.

pH (H2O)	Total C	Total N	P (Olsen)	K	Ca	Mg	Sand	Silt	Clay
	%	%	ppm	cmol/kg	cmol/kg	cmol/kg	%	%	%
4.2	0.4	0.05	16.7	0.077	0.50	0.108	86	8	6

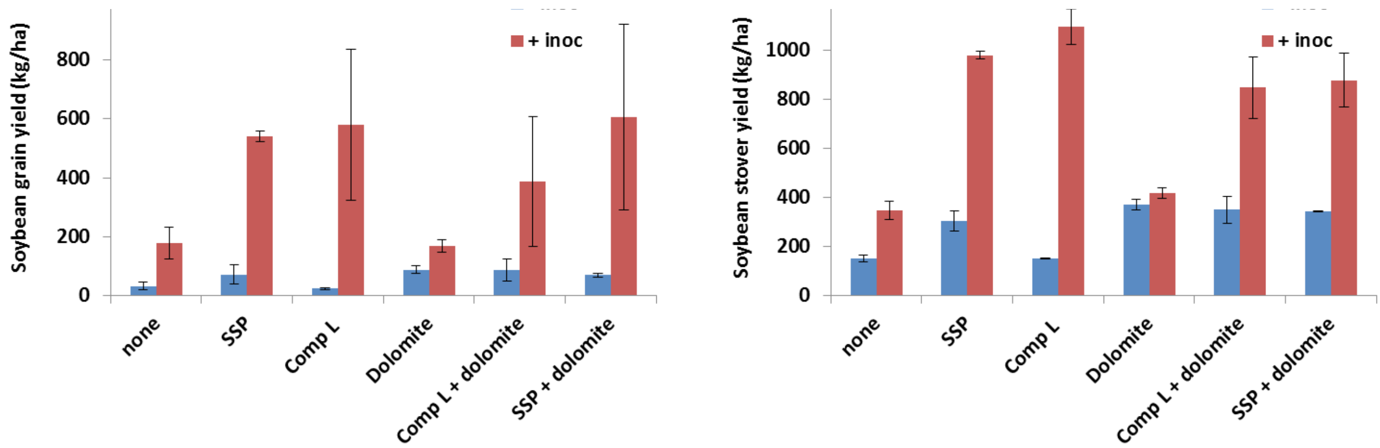

Fig 3. Soyabean grain and biomass yield with different fertilizer applications in the trial in Murewa.

of P-based fertilisers (Fig 3). Compound L (NPKS) as well as single super phosphate (P, Ca and S) were used as P sources at a rate of 20 kg P/ha. An effect of the additional nutrients in Compound L was not visible, despite the low K status of the soil. Dolomite provided both Mg and Ca at 15 kg/ha and 27 kg/ha, respectively, and their addition did not improve yield in comparison with the control. Response to inoculation was strong in this poor soil, implying low effective numbers of rhizobium in the soil. Thus, even though yields were low due to the combination of poor soils and poor rainfall, the use of P-based fertiliser and inoculants led to a several fold increase in yield. Even without P there was a strong response to inoculation, and with P the response was very large.

Why such low yields?

The legume yields achieved in the 2010-2011 agronomy trials were generally poor for a number of reasons. Most trials were located in Murewa, where the bulk of the soils are granite derived sandy soils with a very poor inherent soil fertility. Institutional challenges led to delayed field selection for experiments, and late planting. The delay in field selection meant that most of the fields selected were outfields because farmers plant their home fields first. Although these outfields are thought to be generally unsuitable for legume production without organic amendments, they represent a large proportion of the cropping land (estimates at ~60% of the available cropped land from earlier work) in the area. Work by other scientists (e.g. Zingore et al., 2008) also reported comparable, poor soyabean yields in this area, especially in the sandy outfields. Low pH and low organic matter content are characteristic of these soils and this means that soyabean production, especially without P application and without inoculation (Fig. 3). Poor rainfall distribution throughout the season (prolonged drought periods especially at flowering) also reduced yields. Nevertheless, the trials clearly demonstrate that without inoculation and P there was virtually no yield (<0.1 t/ha), but even on these poor soils, in a season with poor rainfall distribution, inoculation and P have major impacts on soyabean yields. Use of inputs can turn crop failure into an economically significant yield of 0.6 to 1 t/ha.

Way forward

In the coming season, we will ensure that technologies are tested on soils with different fertility characteristics, including soils with a high potential for legume production. When trials are established on poor sandy soils, cattle manure will be applied at a rate of 5 t/ha. Moreover, the set-up of the agronomy trials will not be the large factorial trials with three replications per site as was done last season. Instead, the same experiments are going to be repeated but with one replication per site, but on a larger number of sites to better cover the diversity of soils. These trials will be managed by the N2Africa researchers to ensure good management of the trials.

In addition, agronomic data will be collected from D&D trials. These are simple trials (e.g. soyabean without Phosphorus or Inoculant; + Inoculant; + Phosphorus; + Phosphorus + Inoculation) that are implemented by farmers and conducted in many sites with one replication per farm. The vast scale at which these trials are carried out will cover the diversity of soils and management better than the agronomy trials, giving key information on which technology works where, and why it does or does not work. To achieve this, the agronomy team will work closely with the D&D team in designing such trials and assist with the collection

of soils and data from experimental fields, trial management by farmer, as well as final crop yield. To add to this a Field Book for technology Evaluation will be administered this season to collect information from lead and satellite farmers.
Moreover, trials on forages will be established across three districts in Zimbabwe coming season. Finally, to better understand the factors that limit legume growth on the very poorly fertile soils, a series of pot trials will be carried out to identify missing nutrients other than nitrogen and phosphorus.

Talkmore Mombeyarara, Linus Franke and Freddy Baijukya

Inoculation and staking systems of climbing bean in Kenya

Climbing bean is one of the legumes under study in Kenya. In contrast to bush beans commonly grown by farmers, climbing beans are higher yielding, have a longer growing period and require support. A field evaluation was conducted with climbing bean (cv. Kenya Mavuno) at 19 locations by project Master Farmers to assess the inoculation (BIOFIX containing CIAT 899) and three alternative staking systems of climbing beans (single staking, tripods and string trellises) during the 2011 long rains (March to July). Inoculation increased nodulation by 15% and yields by only 6%. Nonetheless, yield increases of only 42 kg/ha provide a return of over $25 after investing only $6 on BIOFIX and may be regarded as a form of inexpensive “crop insurance”. Tripods were the highest yielding staking system, increasing yields by 40% above single staking. Interestingly, tripods require 33% less stakes and the availability of staking materials often controls farmer’s willingness to adopt climbing bean. String trellises were variable, with each Master Farmer provided two rolls of nylon line that were arranged as they saw fit. Strings arranged vertically performed better. These trials were conducted entirely by Master Farmers, not randomized and irregularly replicated, and yield and nodulation assessments conducted by them, so these findings are regarded as preliminary. More detailed assessment of climbing bean management is underway by the Kenyan Legume Agronomy team and will be reported in a future Podcaster.

Table 4. Effect of inoculation and staking system on climbing bean in west Kenya (± Standard Deviation).

Management	Yield (kg/ha)	Nodules (no/plant)
No inoculant w/single staking	688 ± 340	26 ± 19
Inoculant applied w/single staking	730 ± 356	30 ± 17
Inoculant applied w/string trellis	998 ± 562	nd
Inoculant applied w/tripod staking	1022 ± 482	nd

Paul Woomer

Lessons learned and way forward in N2Africa’s agronomy work

The results of the agronomy trials so far have provided a wealth of information, some of which presented in this podcaster. However, the agronomy team has also faced a number of challenges and results were not always as anticipated. The problems faced so far provided important lessons for the agronomy team leading to changes in the N2Africa research strategy. Below we share the the main lessons we have learned and the way we are adapting our approach.

Lessons learned

Institutional vs. biophysical challenges

While the trials have yielded interesting results, it is recognised that the lay-out and implementation of the trials in the previous seasons was often not ideal. In some trials, yields were very low and treatments effects were minimal. It is important here to distinguish, as far as possible, between poor yields caused by institutional problems and poor yields caused by biophysical challenges. Institutional problems (late contract signing, poorly-trained field staff, confusion about roles and expectations, etc.) sometimes led among others to a poor selection of sites, late planting, poor crop management, poor data recording and, in some cases, the complete abandonment of trials. Biophysical challenges (droughts, pests and diseases, poorly fertile soils) were often confounded with institutional problems. For instance, late planting may lead to a higher risk of drought during the crop cycle, or late arrangements with farmers led to the selection of highly infertile outer fields as trial sites (as these were the fields not yet planted). That said, we recognise that farmers have a wide range of planting dates due to labour constraints and other priorities. Further, much of the land available for crop expansion tends to be in a fairly degraded state in countries where population density is high. The emphasis needs to be on ensuring that technologies are tested across the full range of conditions encountered by farmers.

Data collection errors and omissions

In the first growing seasons, some errors were made during data collection. In a few instances, plant samples have gone missing or there were errors in labelling of soil samples. A common error was the use of coarse scales for weighing the total fresh pod weight. For instance, fresh pod weight was sometimes measured with an accuracy of 100 g while total weights from the harvested plot was only 500-1000 g. As this weight is the basis for calculating final dry grain yield, such errors seriously compromise the value of the yield data. In addition, precipitation data were not collected at most sites. Rainfall data currently available are estimated through satellites and may not always accurately reflect the situation on the ground.

Non-responsive soils

Trials were frequently located on very poorly fertile soils. While in some cases, N2Africa technologies led to spectacular yield increases (e.g. from 50 kg to 600 kg soyabean grain per ha as a result of using inoculants and P fertiliser in Zimbabwe) on such sites; in other cases there was barely any response to inputs. Therefore the soil may also be referred to as non-responsive soils. Further research in N2Africa will focus on identifying the biotic and abiotic factors other than N and P availability that limit growth on these non-responsive soils.

Covering the diversity of soils and climates

The type and lay-out of the agronomy trials in previous seasons (fully replicated randomised block designs with usually one trial representing a particular agro-ecology) obviously cannot cover the wide heterogeneity in soil fertility of fields within farms and between farms in a region. To draw conclusions on which technologies work where, and why they work, technologies need to be tested at a larger scale across the full range of environments. The demonstration and dissemination (D&D) trials, which are simple with a single replicate at each site, offer great opportunities to cover the heterogeneity of farmers' conditions, given the large number of trials that are carried out. The Agronomy teams in the various countries have therefore started systematic data collection in a selection of D&D trials. This requires close collaboration between D&D and agronomy teams. The prime objective of the D&D trials remains the transfer of knowledge and skills to farmers and their communities, but we can learn much more from the D&D trials through measuring performance.

The way forward

- Where national partners experienced problems in execution of the trials we have increased the direct involvement of the local N2africa agronomist in the implementation of the trials. We recognise that the N2Africa project has an important role in capacity building. The need to implement trials well and the need to build capacity of national institutes, even things did not go well in the previous seasons, will be carefully balanced.
- Contract signing with partners and the planning of the agronomy trials has become timelier and will avoid delays during the growing season. This is likely to lead to a better management of the trials.
- More attention is given to timely site selection, so the trials can be located on a variety of soils with different fertility characteristics.
- Technicians have been further trained in the collection of yield data. There has been a major effort to ensure that all weighing scales used in the field are sufficiently accurate and that rainfall data is collected at each site with the help of rain gauges.
- Work on the identification of limiting factors in non-responsive soils has started or has been planned in the coming season (e.g. missing nutrient trials with pots in greenhouses have been initiated in Nigeria and Zimbabwe). Also more attention is devoted to the control of biotic stresses in trials. Some of this work is funded by the supplementary N2africa grant.
- The agronomy teams have started data collection activities in D&D trials. To facilitate this, a Field Book for Technology Evaluation has been developed. This includes the collection of general farm characteristics, planting and germination data, crop management data, yields and soil analyses. The aim is to monitor roughly 300 D&D trials per country.

The agronomy team is especially excited about the prospect of collecting data in large numbers of D&D trials. The team is also grateful that a supplementary grant to N2Africa from the Bill & Melinda Gates Foundation will allow the team to increase its research efforts through the appointment of an additional research assistant in each country and extra operational funding for work on non-responsive soils and soil analyses.

Linus Franke, Freddy Baijukya

The Podcaster is published each month – we look forward to receiving news and contributions – particularly from partners. Please send in contributions by the third week of each month. Contact address for this newsletter is: N2Africa.office@wur.nl

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

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