Soil nutrition, fertiliser and tailoring blends

Thematic insights from delivering technical assistance to agribusinesses through the African Agriculture Fund’s (AAF) Technical Assistance Facility (TAF)
INTRODUCTION

The AAF Technical Assistance Facility (TAF) provided technical assistance to support AAF investee agribusiness to design, test and implement inclusive business models to enhance both commercial returns and development impact. This often involved supporting AAF companies to integrate more smallholder farmers into their supply chains, both upstream and downstream.

Downstream activities involved working with 4 AAF companies to develop and distribute cost-effective agricultural inputs, equipment and services to farmers as customers. This paper documents the lessons learned from downstream technical assistance interventions with 2 of these businesses, an inorganic fertiliser blending and distribution company in Malawi and an organic guano mining and distribution company in Madagascar. The TA interventions with these companies covered several ‘inputs’ to the smallholder farming system including extension, finance, seed and fertiliser. The focus of this paper is on the findings related to fertilizer, namely conclusions from soil testing, blending, demonstration and marketing initiatives.

The AAF TAF experience confirms the importance of testing various input options to determine appropriate combinations of products and practices to optimise farmer incomes. We conclude that while improved blends must be part of the solution to ensure long-term soil health and viability; timeliness, technique and crop diversification also have a significant impact in terms of yield. Innovations in fertilizer product need to be accompanied by additional farm services, such as field demonstrations, advice and data, to drive uptake and sales by building a more profitable and resilient smallholder farmer customer base.

Fertilizer primer

Fertilizer is one of the fundamental inputs for successful agriculture, alongside high quality seeds, water, and crop protection products. Fertilizer use in Africa is incredibly low compared to developed markets and even other emerging markets. While over-use of fertilizer is a legitimate problem – particularly in China – under-use of fertilizer and good soil nutrition practices more generally leads to substandard productivity in the short term and long-term soil nutrient depletion in the long term.

In 2006, average fertilizer use in Africa was about 8 kg per hectare—a tenth of the global average. In that same year, African Union member states met in Abuja, Nigeria and adopted the “Abuja Declaration on Fertilizer” pledging to increase fertilizer use to 50 kg per hectare by 2015. However, the average fertilizer application in Africa today is still low between 13 and 20 kg per hectare. In all of the African countries where AAF TAF had inclusive business projects the average kgs of fertilizer applied per hectare was less than half of the world average of 138 kgs/hectare. Only in Zambia and South Africa are they approaching the Abuja target of 50kg per hectare. In Malawi and Madagascar the average fertilizer usage is less than half the Abuja target and less than a sixth of the world average.

![Figure 1: Average fertilizer consumption in AAF TAF project countries](source: IFASTAT 2016)

From a yield potential perspective, this presents a huge opportunity with the ability for farmers to meaningfully increase the amount of crops they produce on the same amount of land. The follow-
ing four factors are important in relation to yield: source of fertilizer for their crop and soil, rate of application, time of application in relation to crop development and growth and, place of application in relation the plant and on or in the soil. The TAF experience relates to testing different types of fertilizer (i.e. source innovations) on yield as well as influencing the rate, quality and timing of application through extension advisory.

Why fertilizer, why blending?

There are a number of strategies to drive critical soil nutrition. Soils can be left fallow allowing nutrients to return but for many smallholders in Africa with limited access to land and with minimal food security, this is often not an option. Alternatively, certain crops such as legumes are said to be “nitrogen fixing” adding back certain nutrients to the soil. One intensive approach to this is crop rotation where a season spent growing a typical food crop is followed by a season growing a “fixing” crop. While such strategies have been shown in Malawi to increase yields by 500kg/Ha to 2.5MT/Ha, the impact is relatively modest compared to the optimal maize yields of 8MT/Ha.

An alternative is strategy is intercropping which has repeatedly been shown to provide economic and agronomic benefits to the farm. However, once again the magnitude of this impact must be contextualised. For example, tests in Malawi which added a pigeon pea intercrop to maize production, led to identical maize yields as without intercropping (1.2 MT/Ha). While this “bonus crop” is clearly beneficial, it is insufficient to increase maize yields on its own.

As such, one of the most important strategies for maintenance of soil nutrition in almost all farming systems is the application of fertilizer, whether this be organic or inorganic fertilizer. Applying fertilizer at the right time provides plants access to these nutrients allowing productivity to be maximised.

However, use of fertilizers that are not tailored to the particular soil conditions will lead to nutrient depletion, poor soil health, and declining yields. In order to revive yields, it is necessary to revise fertilizer blends periodically – based on the current soil conditions to improve soil health as well as to provide crops the nutrients they need. Using tailored fertilizers can meaningfully improve yields in the short term, and ensure viability of the soils in the long-term.

Defining the concept of “fertilizer tailoring”

The premise of tailoring fertilizers to the crops grown, and the soils in which they grow, is universal. The way in which this is done, particularly the level of granularity at which it is done however, varies substantially. In developed markets, like the U.S., with commercial farm sizes, fertilizer blends are tailored at the farm level. Soil testing can be done at the farm level to establish the precise nutrient and micro-nutrient requirements. Precision agriculture techniques allow for nutrition and product development to even be varied within the farm.

However, this approach is typically not feasible or economically viable in smallholder farming systems in Africa. In an African smallholder context, the level of tailoring is typically done at a much higher level. With fertilizer markets much smaller, with farm sizes much smaller, and with the need to drive improvements from a much smaller base, soil testing and blend tailoring is often done at a national level, with the economics of tailored blends at a micro-level typically breaking down. Furthermore, in markets where certain products are provided on subsidy to farmers, defining the right national blends for a particular crop is more feasible than tailoring a fertilizer to a specific farm, particularly when looking at smallholder staple crops like maize and rice.

In this context, we observe a number of problems: government recommended blends may be twenty or thirty years old and not updated to take account
of national crop diversification strategies or more recent changes in soil nutrient depletion. The need for improved fertilizer blends in Africa is well documented\(^1\) in order to increase productivity and address the long-term soil depletion that has occurred. AAF TAF initiatives aimed to contribute to efforts to address this need in Malawi.

**CASE STUDY: MERIDIAN AND TAILORED BLENDS IN MALAWI**

**Background to Fertilizer in Malawi**

Malawi is a typical example of a sub-Saharan African country that needs evolution not just in the quantity of fertilizer used but also in the type of fertilizer. Malawi is only 118,000 km\(^2\) in area, yet it has a very diverse agro-ecology, with 55 natural regions. The varied terrain and soil types make blanket fertilizer recommendations sub-optimal. The government of Malawi has, over the last three decades, succeeded to improve fertilizer access by smallholder farmers, while national and international research organizations have conducted research activities aimed at enhancing fertilizer use efficiency in Malawi. The fertilizer subsidy program implemented by the Malawi Government has led to increased fertilizer supplies from 14,237 metric tons in 2005 to 216,553 metric tons in 2009 (IFDC 2013). This translated to increasing fertilizer use intensity from less than 20 kg ha\(^{-1}\) in 2000 to 43 kg/HA in 2009 (IFDC 2013).

Although the average crop yields in Malawi have increased in tandem with increase in use of fertilizers, the economic and agronomic efficiency of using fertilizer has levelled at less than 50% of potential. Current fertilizer application is based on blanket recommendations that focus on N and P, and to a less extent S. The main food crop in Malawi is maize and the government recommended fertilizer is basal dressing (NPK 23:21:0 +4S) and top dressing Urea (46% N). It has been the recommended fertilizer in the country for 35 years.

This is a critical development issue that needs to be addressed, as continued use of inappropriate fertilizer will undermine agricultural productivity. It is also a commercial opportunity for fertilizer companies looking to grow their business in Malawi. Products that are better tailored to the soil conditions will have higher efficacy, driving higher yields and delivering greater benefits to farmers, the main user of the products.

**Background to Meridian**

Meridian is an agricultural commodities company based in Mauritius and operating across Malawi, Mozambique, Zambia and Zimbabwe. Its core focus is on the importation, blending and distribution of fertilizer. Raw fertilizer materials for Malawi are imported into Mozambique and transported by rail to Malawi.

In Malawi, the Meridian group has two retail chains: Agora (in the southern region) and Farmers World (in the central and northern regions). Originally established in the 1990s to distribute fertilizer to smallholder farmers across the country, today the company has a network of 110 depots that function as one-stop-shops providing farmers with all their day-to-day needs, in addition to a range of standard fertilizer products.

At the time of TAF scoping in early 2015, it was clear that Meridian management saw the opportunity to differentiate itself by delivering tailored fertilizer blends to smallholders but had not taken steps to develop this model due to the commercial risk for the business. The considerations at the time can be summarized as follows:

---

\(^1\) Mutegi et al (2015) Fertilizer Recommendation Status, Gaps & Opportunities
The Productivity Improvement Programme for Smallholders (PIPS)
- **Opportunity:** By developing improved, differentiated products, Meridian would be able to drive brand loyalty with its farmers and increase market share in an increasingly competitive commercial environment. Furthermore, given that Meridian sells and markets its fertilizer products through its own agri-retail chain of 110 depots, it had a unique ability to leverage these locations to educate farmers on the benefits of improved blends. The ability to combine product innovation with farmer-level extension could be a critical success factor for driving uptake of new products, an opportunity that was not available to the company’s competitors.

- **Risk:** The risk was both on the supply and demand side. On the supply side, the cost of soil testing and associated blend analysis was deemed too high for the amount of product that could be sold in the low-cost fertilizer market. On the demand side, smallholders were used to a particular product, so driving a shift to a new fertilizer product would also incur a high ‘edu-marketing’ cost that could not be covered by a premium given the low purchasing power of smallholders.

To help test and realise the development opportunity of the model TAF proposed to de-risk the venture, by co-funding R&D related to the development of tailored blends as well as a piloting an extension model to help Meridian provide the associated information to farmers on how to optimise their investment into higher quality inputs.

In 2015, a proposal led by the African Fertilizer and Agribusiness Partnership (AFAP) was selected to implement the pilot in the central region of Malawi. Their approach was based on using SoilDoc, a portable soil testing kit developed by Columbia University. SoilDoc

---

**Box 1: Understanding different soil testing technologies**

Tailoring solutions for good soil nutrition requires soil testing. Soil testing is an integral part of many decisions in fertilizer development and marketing: it can be used to better understand the pre-existing nutrient characteristics and deficiencies to inform development of new blends, as was done with Meridian. It can also be used with farmers as part of the marketing and extension process, to help them better understand the particular nutrient characteristics and deficiencies of their farm.

The traditional form of soil testing is laboratory based wet chemistry. In this model, samples are collected from the field, and sent to the field for chemical tests. Despite myriad innovations in the soil testing space, the consensus is that this remains the most accurate approach and can test for the broadest array of micronutrients. It also tends to be a more expensive solution and relatively slower.

Innovations in the soil testing space have tended to operate on two dimensions. Firstly, bringing the soil testing to the field with various “mobile” kits. Secondly, shifting to reflectance spectroscopy, (particularly near infra-red or NIR spectroscopy) to reduce cost and increase access. On the first dimension, mobile wet chemistry ostensibly brings accuracy and breadth of nutrient analysis to the field. However, operation of the model in the field requires a relatively high level of technical proficiency. It also requires performing complex chemical processes, not always straightforward in contexts.
offers the advantage of testing in-field and rapid results, as opposed to sending samples to be tested outside Malawi, which can be an expensive and slow process. In addition, the project hired 30 agronomists to collect and test over 2,000 soil samples, and to provide advice on good agricultural practices to smallholder farmers. These staff were known within the company as ‘agronauts’ – a term to convey the intention to harness the latest in science and technology to support farmers in making evidence-based agronomic decisions.

Ahead of the 2016-17 planting season, the network of 30 agronomists used 15 SoilDoc kits to collect 2,278 samples in the Central Region of Malawi. The kits were able to test for macro-nutrient presence (N, P and K) and certain micronutrients (mainly S). To test for micronutrients, a smaller number of samples were collected and sent to CropNuts in Kenya, an organization that provides laboratory soil testing services. The results from both services were sent to Columbia to develop soil maps for the sampled areas in the central region.

The SoilDoc team produced store-level maps and used the results of the soil testing to develop five new crop-specific blends:

- **Maize**, 15:23:16: +6S +0.5Zn +0.3B for basal and a 30:0:16 for top dressing
- **Soybean and groundnut**, 6:20:24 +3S +0.5Zn +0.3B blend
- **Sweet potato** 10:20:20 +6S for basal, and a 25:0:27 for top dressing

Like Malawi. Finally, while results are made available much quicker, operating this mobile model across 2,000+ locations may not necessarily provide meaningful cost savings.

On the second dimension, **reflectance spectroscopy** establishes soil nutrition by reflecting light on the soil. The simplicity of the testing, the absence of harmful chemicals, and the ability to generate results quickly are some of the benefits. Mobile versions of the model are easy to operate. However, there is consensus that the approach is less accurate, with the level of inaccuracy dependent on the amount of calibration data that is available for the particular context. Furthermore, the approach cannot test for micronutrient deficiency. While there are issues with inaccuracy, the relative accessibility and affordability for smallholders, and the ability to generate large scale soil maps by combining with satellite imagery means these approaches offer much promise.

**Figure 2: Soil nutrient limits – Farmers World central region branches (SoilDoc 2016)**

This project was primarily funded by the EU, managed by IFAD and implemented by TechnoServe. The project received additional donations from the Alliance for a Green Revolution in Africa (AGRA), Italian Development Cooperation and United Nations Industrial Development Organisation (UNIDO).
To test these blends, the project set up 60 demonstration sites during the 2016-17 season across the Central Region of Malawi. These were set up in conjunction with 30 of the company’s Farmers World Shops through which it sells and buys agricultural commodities. At each site, the company tested 12 different fertilizer treatments across three crops. 10 x 8 meter demo plots were managed by a host farmer and technical oversight was provided by the local agronout. Across the demo plots, the company compared use of improved blends vs. the existing options and vs. not using fertilizer at all.

The results of the first season demos showed promising results from the application of an improved blend when compared to a standard blend (in the case of maize). However, results were hard to interpret because the treatments were applied at different kilogram per hectare rates. This made it difficult to compare the return in terms of kilogram yield per kilogram of fertilizer applied. Results for the legume blends were also promising particularly when combined with the application of agricultural lime.

Due to the challenges with the SoilDoc mobile wet chemistry kits (see box 1) ahead of the 2017-18 planting season it was decided to use the more conventional laboratory wet chemistry approach for a Southern Region soil baseline. An additional 30 agronouts were hired. 523 samples were collected in the Southern Region for full macro- and micro-nutrient analysis by CropNuts.

The results of the second season demos were much easier to interpret due to the simplified protocols of the trials. The standard blend and the improved blends were applied at the same rate, making comparison much easier. Based on the results of the CropNuts Southern Region trials, refined blends were trialed in the South that addressed the nitrogen and sulfur deficiencies (through the application of additional ammonium sulfate).

The performance of the new blends in 2017-18 was substantially better than the existing government recommended option. The new Meridian “Mwininthaka” blend generated 18% higher yields than the government recommended fertilizer on maize, and 30% higher yields when used with soy. A double application of fertilizer on maize plots resulted in yields of 7MT / Ha, roughly three and a half times what the typical smallholder farmer receives in Malawi, and approaching the 8MT/Ha benchmark of optimal yields typically expected for maize.
MARKETING IMPROVED FERTILIZER

Having proven that the new blends deliver improved agricultural productivity, Meridian needed to develop a marketing strategy to persuade farmers of the efficacy of the new products. The new blends were branded under the Mwininthaka name which means keeper/owner of the soil in Chichewa, the local language in Malawi. The name was selected to remind farmers on the importance of protecting the long-term health of their soils. In Africa, where farmers associate particular fertilizer products with a particular bag colour, Meridian developed a distinctive coloured bag for each blend and put a photo on each bag associated with a particular crop. The company also developed posters that would be displayed in stores and pamphlets that showed pictures of the new product.

The new Mwininthaka line goes on sale later this year at which point Meridian will have sufficient data to establish how successful its new product has been in driving sales and gaining market share. However, even at this early stage there is evidence that the journey has been a success.

The robust approach to soil testing and blend development has allowed the company to deliver a product that delivers ~20% more benefit than existing alternatives. With the company planning to align price with existing products on the market, this should provide substantial competitive advantage. Meridian’s unique Agronaut distribution network should allow for effective marketing of the benefits.

From a development perspective, the benefits are also clear. Tailored blends will ensure the long-term viability of the soil and therefore the long-term security of Malawi. They will help ensure yields – not just fertilizer intensity of use – which is critical for the food security of the nation.

CASE STUDY: ORGANIC FERTILIZER, GUANO AND ESTABLISHING NUTRIENTS

Organic Fertilizer and the Role of Testing

In addressing the issue of soil mapping and tailored blends in sub-Saharan Africa, case studies tend to focus on the inorganic fertilizer segment. However, the principles of soil testing are equally relevant in the organic fertilizer sector. Organic fertilizer is a key strategy adopted by farmers around the world to maintain soil fertility. The segment includes naturally occurring organic fertilizers such as manure, guano, peat, and animal waste from meat processing. Organic fertilizers can either come in their “raw form” or pelletised.

While coming from a different source to inorganic fertilizer, the principles of soil nutrition and testing remain the same. However, whereas with inorganic fertilizer, the chemical composition is defined by the manufacturer, with organic fertilizer the chemical composition is often naturally occurring. As such, it is critical for companies that are looking to develop organic fertilizer businesses to establish the chemical composition of their fertilizer and establish how farmers should use it in tandem with other soil nutrition approaches.

Background to Guanomad

Guanomad is a Madagascar based company that specialises in the production of fertilizer from guano, the excrement of bats, which is found in caves. The company sells 50% of its product domestically to farmers in Madagascar, with the remainder exported.

Guanomad has access and the mining rights to a vast network of caves containing guano throughout the country. An independent audit of the guano reserves within this network estimate the reserves to be ~2 million tons. The company has only explored and verified about 50% of caves in the network and typically only accesses caves when current reserves are exhausted and/or a...
different type of guano is required by the client. The nutrient composition changes significantly between the cave systems which is typically driven by ecological factors related species, diet and weather. When a new cave is discovered, villages from the surrounding area will alert Guanomad who then conduct a mission to the cave to analyse the accessibility and composition of the caves and guano. Villages from the local area are employed as labourers should extraction be required which stimulated local economic development by providing much needed jobs.

Extraction is done with the highest degree of consideration for the health of the bat populations that reside in the caves. For instance, extraction may occur at night when the bats are hunting and no heavy equipment is ever used. The business has two production plants in Tulear and Antananarivo which serve as depots and blending facilities.

Guanomad has been supported by TAF across both the agricultural value chain and business development support projects. In total 8 projects were completed over 5 years focusing on developing a local and export marketing strategy as well as demonstrating the value of Guanomad’s products to local smallholder farmers.

Establishing Nutrient Content of Organic Fertilizer

As Guanomad looks to scale its operations, it is critical for the business to accurately establish the nutrient content of its organic fertilizer product. Furthermore, it is important for the business to establish variations in nutrient concentrations by region and mine so as to increase the efficiency of its mining operation and understand the implications of mining in certain geographies. Moreover, by understanding these changes it can respond adequately to client demands.

As such, Guanomad, supported by TAF, proceeded with an extensive set of tests of guano produced at a variety of locations to determine the origin

**Box 2: Organic Fertilizer: A Primer**

The term organic fertilizer captures a very broad set of soil nutrition approaches, only one of which is guano (described above). Given the ubiquity of the phrase, it is helpful to define it further. It is fertilizer derived from plant or animal matter, as opposed to NPK fertilizers which are mined (phosphate rock) or produced industrially from hydrocarbon sources (ammonia). However, given some organic fertilizer can be mined (guano) and other organic fertilizer go through extensive industrial processes, it is maybe more helpfully defined as coming from replaceable sources and/or undergoing less processing.

The most common form of organic fertilizer is derived from waste: plant waste which is most commonly turned into compost or animal waste in the form of manure or guano. Other common forms of naturally occurring organic fertilizer include peat, which is a form of plant waste.

There are a broad variety of inputs that can be used to develop organic fertilizer. However, the more relevant segmentation tends to be between processed or natural organic fertilizer (i.e., compost or manure in its raw form) and organic fertilizer which has been processed to be sold commercially (conversion of these raw materials into pellets. As with inorganic fertilizer, these processed products should state the macronutrient content as part of their labeling.

Organic fertilizer in both its raw and pellet form tends to have lower macronutrient intensity than inorganic fertilizer. However, users tend to identify a variety of other benefits from organic fertilizer use including: slower release of the relevant nutrients and reduced risk of over-fertilizing. Some organic fertilizers may also include other organic material that is beneficial to the soil. These benefits are typically cited alongside the environmental benefits of sourcing the fertilizer from more renewable sources.
of guano variability and to develop spectroscopic tools to quickly characterize the guano fertilizing properties. To do this, the company took 1,238 samples of guano from different cave systems and locations within the caves, conditioned and dried them, and submitted them to infra-red spectroscopy analysis. This raw data was then analysed and submitted to various regressions to establish what factors drive guano variability. To provide a viable comparison with the spectroscopy technique, wet chemistry analysis was also conducted drawing from the same sample set.

The results of this analysis were used to characterize the nutrient content of different regions and of individual caves within regions in Madagascar. This was then used to construct a predictive model for the specific nutrient content of a bag of guano depending on where the guano had been mined. So far, the prediction models have shown a high predictive value although Guanomad plans to continue to refine the model by conducting more reference analyses to ensure calibration of the technique is robust. Moving forward, the business will market guano based on the verified NPK nutrient composition from the spectroscopy technique rather than generic values which tended to be inaccurate and required further blending with other organic additives driving up costs.

**Testing the Efficacy of Organic Fertilizer**

Demand for organic fertilizer globally is growing, particularly among customers for whom organic production methods are a moral or health priority. This growth has tended to be most acute in developed countries and/or larger commercial farms which have committed to such an agricultural approach as a strategic imperative.

However, Guanomad also wants to grow its business within Madagascar itself, which like most of sub-Saharan Africa, is dominated by smallholder farmers whom tend to be poor and who have some of the lowest adoption rates of fertilizer in the world. To target such a customer base, it is critical for Guanomad’s product to be competitive with inorganic incumbents in the market, where competitiveness is defined as product efficacy (in driving yields) relative to the cost of the product.

TAF funded a set of field demonstration plots and trials to establish the efficacy of guano vs. alternative fertilization strategies. In total, 10 demo plots were established in Vakinankaratra and 5 trial plots were installed at the CEFFEL research center in Antsirabe. CEFFEL is a leading farmer research centre that was contracted to conduct experiments on the effect of various fertilizer treatments on the yield and cost benefit of 3 types of vegetables. The fertilizer treatments included guano, inorganic fertilizer as well as two guano-NPK blends. The blends were tested to assess whether there was any agronomic or economic rationale in their use compared to the sole use of guano or inorganic fertilizer. The table below shows the different scenarios that were tested.

**Figure 4: Fertiliser treatment trials conducted by CEFFEL (2016)**

<table>
<thead>
<tr>
<th>Fertilizer treatments</th>
<th>Crops tested</th>
<th>Potato</th>
<th>Carrot</th>
<th>Onion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code</td>
<td>Dose per Are</td>
<td>Local variety</td>
<td>Amazonia</td>
<td>Local variety</td>
</tr>
<tr>
<td>D0</td>
<td>3 KG</td>
<td>-</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>D1</td>
<td>1.5 KG</td>
<td>7 KG</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>D2</td>
<td>0.5 KG</td>
<td>3.5 KG</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

This project was primarily funded by the EU, managed by IFAD and implemented by TechnoServe. The project received additional donations from the Alliance for a Green Revolution in Africa (AGRA), Italian Development Cooperation and United Nations Industrial Development Organisation (UNIDO).
The scenarios chosen were informed by initial analysis of the nutrient content and cost of guano that strongly indicated that guano alone would struggle to be cost-competitive with NPK fertilizer, particularly given its low levels of nitrogen. As such, the trials were particularly focused on how guano could be combined with inorganic fertilizer to optimize results and make best use of the product’s qualities. Scenarios were selected so that the cost of inputs was roughly equivalent in all scenarios. As such, higher yields would serve as a good proxy for higher farmer profits.

The table below shows the impact of the different treatment on yields. In almost all instances for potato and onion, yields from using NPK were higher than for guano alone or for guano-NPK blends. This has been attributed to the low level of potassium present in the guano. The results for carrot were more mixed with guano-NPK blends competitive with just NPK in certain scenarios. As predicted before the tests, guano alone was shown to lag NPK the most.

The reason for guano lagging NPK is relatively simple: at the comparable price point, the total nutrient content of guano is substantially less than NPK - the reduced level of potassium and in some cases nitrogen in the guano means it is not as optimised as chemical equivalents. Moreover, given that organic fertilizer is slow release by nature, yield benefits are typically not seen in the first season of application. On the basis of the above analysis, it is thus difficult to assess the benefits of organic fertilizer from one season of demo plot trial. Further testing is required over multiple seasons.

Results showed that when guano is combined with NPK, in some instances the results can be equivalent to NPK. In these instances, the benefits of guano, including the slower release of nutrients are likely to provide additional benefits to the soil. Finally, where farmers are targeting customers willing to pay a premium for organic quality off-take, guano provides a compelling organic fertilizer option to smallholders in Madagascar, certainly preferable than not using fertilizer at all. However, the results did show that Guanomad’s marketing and growth in Madagascar would need to be focused around its complementarity with NPK (rather than as a replacement) and on emphasising the other longer term benefits that organic fertilizer would bring.

A broader lesson from the work with Guanomad is the importance of placing farmer ROI at the heart of assessments of different fertilisation strategies including an assessment of the crop selection. Emphasising the benefits of organic fertilizer, beyond pure economic considerations, is important. However, establishing the efficacy and ROI for farmers, particularly when they are smallholders living below the poverty line is critical, both in ethical terms but also in business terms as it will inform the viability of a smallholder-centric strategy.

Figure 5: Results of fertiliser treatment trials conducted by CEFFEL (2016)

<table>
<thead>
<tr>
<th>Code</th>
<th>Dose per Are</th>
<th>Crop Yield MT/Ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Potatoes</td>
<td>Carrot</td>
<td>Onion</td>
</tr>
<tr>
<td>NPK</td>
<td>Guano</td>
<td>Local Var.</td>
</tr>
<tr>
<td>00</td>
<td>3 KG</td>
<td>-</td>
</tr>
<tr>
<td>07</td>
<td>1.5 KG</td>
<td>3.5 KG</td>
</tr>
<tr>
<td>01</td>
<td>-</td>
<td>7 KG</td>
</tr>
<tr>
<td>03</td>
<td>0.5 KG</td>
<td>6 KG</td>
</tr>
</tbody>
</table>
Other yield attribution factors

TAF’s work with Meridian and Guanomad was instructive in helping refine and pixilate the often simplistic picture that more fertilizer is better. In Malawi, intensive soil testing has allowed Meridian to bring to market a superior product that should increase yields by 18% vs. incumbents. Through the work with Guanomad, demo plots have helped provide greater clarity on both the opportunities, and challenges, of innovative organic fertilizers, while testing of the caves themselves have provided greater insight into what factors drive the nutrient content of fertilizer. As fertilizer companies look to grow their business in sub-Saharan Africa, continuing to refine and optimize their product for the particular crops and soils that farmers grow will be critical.

However, through this journey we have also learned that optimized soil blends are just one of the factors that drives yields and that as companies think about their critical paths for success, improved soil blends need to be placed in the proper context.

Across sub-Saharan Africa, a challenge that emerges repeatedly is the late application of fertilizer. Farmers typically wait till the last possible moment before purchasing fertilizer, which they interpret to be the first rains. In turn, this means all farmers tend to buy fertilizer simultaneously placing substantial pressure on very weak supply chains and frequent stock outages in the store. These demand side drivers of late application are complemented by supply side factors with fertilizer companies often failing to accurately project demand and/or failing to get the product into warehouses on time. For these, and other reasons, late application of fertilizer is a chronic problem in sub-Saharan Africa. In Malawi, where Meridian has run its soil tests, applying fertilizer 2-4 weeks late has been shown to decrease yields by as much as 50%. Or to frame in the inverse, applying fertilizer on time, doubles projected yields. The chart below illustrates indicatively what this means for yields.

Incorrect application of fertilizer and/or poor agricultural practices dramatically decreases yield across sub-Saharan Africa. Many of these practices require more time but are often cheaper than fertilizer application. There are various examples of this phenomenon but a particularly compelling one also comes from Malawi. Agricultural trials there show that a farmer using 50% of the recommended quantity...
of fertilizer but weeding twice can achieve the same yields as a farmer that uses 100% of the recommended amount of fertilizer but weeds once. Weeding is a time consuming process and not without some opportunity cost for a farmer; however it is certainly substantially cheaper than doubling the amount of fertilizer purchase. While weeding twice and using 100% of the amount of fertilizer would be preferred and optimal, farmers often lack the cash to do this. In a world in which fertilizer companies are trying to maximize farmer re-purchase levels in a cash constrained environment, communicating the importance of weeding alongside fertilizer would result in farmers generating a far higher ROI from their fertilizer, driving higher loyalty.

Another example of the impact that good agricultural practices can have can be observed in Meridian’s own demo plots in which farms using no fertilizer at all achieved 2.5MT/Ha. This is higher than some farms in Africa which do use fertilizer.

This shows the importance of a whole array of practices beyond fertilizer which can transform productivity. Analysis conducted previously by TechnoServe for the Gates Foundation shows that fertilizer efficacy in trial plots is typically 50% higher than observed on actual farms.

We highlight these examples to signal the importance in fertilizer supply chains of the product being available on time, applying it on time, and applying it in the correct way preferably in tandem with low cost good agricultural practices. Timeliness and technique have a substantially bigger impact in terms of yield in the short term than optimized product. Improved blends must be part of the solution to ensure long-term soil health and viability. However, for both development impact (in terms of higher farmer incomes) and business growth (in terms of growing fertilizer market), it needs to be combined with other factors that will drive adoption and re-purchase rates.

**KEY TAKEAWAYS**

1. Fertilizer and increased productivity allow for increased production to come from intensification rather than extensification. Intensified agriculture allows farmers to better feed themselves and their families on the same amount of land, while simultaneously planting crops that they can sell into the market.

2. Tailored blends – not just fertilizer intensity of use – can be used to drive productivity growth.

3. Soil testing analysis is required for recommending tailored blends for different soil conditions. Wet chemistry laboratories are still a cost-effective solution for accurate analysis to inform new blends. Mobile soil testing kits, while operationally complex and less cost-effective, present an opportunity to provide ‘on farm’ advice on practices as well as product application.

4. Edu-marketing is required to ensure new fertiliser products speak to farmer needs/interests; in particular to communicate scenarios of the new product impact on farm economics.

5. New products need to be complemented with extension to ensure optimal yield benefits supported by best agriculture and input application practices.

**Key contact:** Abigail Thomson (athomson@tns.org)