Important lessons from new tailor-made services for smallholder farmers

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Abstract: *Mobile phone technology enables farmers to share information and receive tailor-made advice on farming practices. The objective of this work is to evaluate farmer perspectives on tailor-made services for improved on-farm nutrient application on smallholder farms in Western Kenya and Northern Tanzania. The service included agronomic advice and delivery of blended NPK fertilizer and hybrid maize seeds on credit. Advice on NPK fertilizer was based on best available geo-information in combination with a field quality assessment of the farmer. Pre- and post-season interviews were held with farmers in 46 villages in Northern Tanzania and Western Kenya. Soil samples were analysed and grain yields were measured in demarked plots. Impacts of the service on food self-sufficiency were evaluated by comparisons with a group of control farmers without tailored and farmers who received the service. Application of blended fertilizers increased grain weights when compared to plots without fertilizer. There were, however, no significant differences between farmers receiving tailored services and the to control group who often used fertilizers from other sources. We conclude that the technology might help to improve farm productivity, but only when combined with a complete agronomic package including pest control, local demonstrations and support of local agents or extension officers in environments where farmers have been exposed to hybrid seed and fertilizer.*

Keywords: *Adoption of innovations, tailored advice, NPK blends, Fall armyworm, mobile phone applications*

Introduction

Crop yields in Africa are severely limited by low input use, calling for increased investments in balanced nutrient applications and sustainable intensification. In the context of poor smallholder farming systems, this means the use of improved seeds plus appropriate composition and amount of fertilizer combined with an improved crop management. Smallholder yield gaps in Sub-Saharan Africa are large; a doubling of production can be realised on the same amount of land using existing technologies (van Ittersum et al., 2016). Increasing and improving fertilizer applications to address nutrient deficiencies is a key aspect to improve crop productivity. However, smallholder farmers lack access to reliable information, access to credit and functional markets. Adoption of proven technologies is hampered by the large variability in yield response to nutrient applications (Ronner et al., 2016; Vanlauwe et al., 2016), even when soil analysis is available (Njoroge et al. 2017), adding to already large investment risks for farmers. Lack of cash and limited credit availability is forcing farmers to select investments that pay-off on the short term, whereas increasing soil fertility or rebuilding soil fertility of depleted soils needs a long term approach. Large and repeated applications of phosphorus (P) are needed to overcome current deficiencies and build soil P stocks, in particular when soils have a high P adsorption capacity.

In most countries in Sub-Saharan Africa (SSA), farmers have only access to generic (‘blanket’) fertilizer recommendations, typically including nitrogen (N) and P. Nutrient requirements strongly vary between (Njoroge et al., 2017) and even within farms (Tittonell et al., 2013), resulting in sub-optimal responses to applied fertilizer. The nutrient use efficiencies and financial returns on fertilizer investments in fertilizer strongly vary between farms across SSA (Tittonell et al., 2008b; Tittonell et al., 2013; Kihara et al., 2016). The spatial variability of soil nutrient stocks is large, yet poorly understood as the number of samples analysed are few and uncertainty in relationships between soil nutrient status determined with a single soil sample and plant responses are large (Njoroge et al., 2017). One of the most challenging aspects is the spatial scale related to processes governing soil fertility, such as management history and availability and application of animal manure, directly affecting the response to fertilizer (Vanlauwe et al., 2006; Tittonell et al., 2007; Tittonell et al., 2008b; Tittonell et al., 2013). Evidently, application of poorly balanced nutrient amounts accelerates mining of soil nutrients, although resilience of soil stocks strongly varies between farms (Njoroge et al., 2017).

During recent years, availability of soil information has strongly improved, detailed maps covering a range of soil properties are now freely available (Hengl et al., 2014; Hengl et al., 2015; Hengl et al., 2017). This would allow for a regional adjusted advise, accounting for differences in soil characteristics within a region. Unfortunately, the resolution of these nutrient maps unfortunately do not allow services to be tailored to farm or field levels where important differences in soil nutrient stocks are found.

Convincing mostly uneducated and often illiterate smallholder farmers to apply more nutrients (requiring investments with a limited short term return) is challenging, even though the long term impact can be positive. Fertilizers are typically compared on price per bag without much attention for nutrient content. This promotes the use of quick responding nutrients, mainly containing N, as effects of P and K applications may be less visible on the short term. An unbalanced nutrition of crops does lead to mining of soil resources with negative impacts on crop yield within a few seasons (Njoroge et al., 2017). Maintaining soil fertility requires sufficient stocks of all immobile nutrients (including all cations), at least replacing nutrient exports with products.

According to Beza et al. (2017), motivated farmers can use mobile data technology to improve knowledge and understanding of spatial (soil) variability. This principle has been applied in the Geodatics project, where mobile technology is used to improve services to farmers allowing them to enhance nutrient management. This is done in three ways. First, mobile phones or tablets are used to collect farm and field data, including past organic and inorganic fertilizer use and crop yields. Second, mobile devices are used to geo-reference the field under consideration. Field location then is linked to soil maps and satellite (NDVI) data, thus allowing the development of location-specific fertilizer recommendations. Finally, information from farms and fields are linked to recommend optimum fertilizer type and application amount in a tailor-made advice which is shared with farmers and field staff via SMS and other mobile platforms.

Incorporating farmer knowledge, soil information, satellite data and scientific information provides a solid basis for an advice which ensures improved nutrient use efficiency and increased return on investment for farmers. The use of mobile technology makes information more easily accessible, either directly or via better informed intermediates and extension services. It also can be combined to mobile banking and credit opportunities which are very popular in the region. The challenge is to develop efficient and cost-effective advisory services that can effectively transfer the advice and other information smallholder farmers.

This paper presents preliminary results of the Geodatics project which was designed to implement mobile data technology to enable a tailor-made fertilizer advice for smallholder farmers. The objective of the paper is to evaluate: the collection and use of mobile data; their application in the setting of data-scarce smallholder farming; and the assess the impact of tailor-made advise on maize production. To this end, we compared maize cultivation by smallholder farmers provided with tailored services in Western Kenya and in Northern Tanzania with a control group without these services.

Materials and methods

The Geodatics project

The Geodatics project is led by ICS and includes four partners covering technical, scientific and commercial partners (Table 1). Collectively the partners collect, transfer and analyse mobile data and use them for tailor-made fertilizer advice for individual fields of smallholder farmers in Kenya and Tanzania. The tailor-made advice is offered as a package to smallholders by Agrics Tanzania and Agrics Kenya (both subsidiaries of ICS) and includes seed, fertilizer credit and agronomic advise. Data collection, submission, transfer and conversion into fertilizer advice depends on effective communication between different partners which each play a unique role in the process.

Table 1. Partners and data transfers.

Partner	Main role	Description
Agrics	Distribution of input packages	Direct contact with farmers, agronomic service and training for farmers, quality checks
Manobi	ICT provider	Data validation, data transfer
Wageningen University	Scientific partner	Data integration, technical advice
Biomass Research	Data management	Design of data transfer and quality protocols

Data management protocols were developed to facilitate the calculation and delivery of customized, tailor-made fertilizer advice adjusted to local weather, soil and farm conditions. Use of geolocations derived from mobile phone apps is key and enables combination of various geodata sources. An overview of all data sources and their characteristics is provided in Table 2.

Table 2. Data collected in the Geodatics project.

Data type	Explanation	Sources
Fertilizer data	Fertilizer types on sale, including nutrient composition and prices	Commercial providers (not included in the project)
Farm data	Farm size, type, animals, risk profile	Farmer (interviews)
Plot information	Location (geo-reference), size, history, soil samples analysed on macro and micronutrient contents	Farmer (interviews); mobile phone; soil analysis
Weather data	Rainfall, temperature, climate zone	Weather stations
Soil data	Major soil type, depth, fertility status, combined with extra	ISRIC, see www.soilgrids.org
Scientific data	Water limited yield potential	See www.yieldgap.org for details
Satellite data	Modis-NDVI	NASA

Serving smallholder farmers

Agrics is a social business originally setup in 2011. Agrics Ltd. Is registered in Kenya and Tanzania, working with about 22,000 smallholder farmers in Western Kenya and Northern

Tanzania. Its main goal is to improve the living standards of smallholder farmers in a sustainable way with an input credit program. Quality agricultural inputs are purchased off-season (when prices are low) and distributed to smallholder farmers on credit at the onset of the production season. Repayment of the loan starts immediately. Farmers' capacity is strengthened by providing access to up-to-date and practical knowledge related (including the proper use of fertilizer and seeds). Agrics also plays a role in facilitation of market access, focusing on important value chains of maize and vegetables in Kenya and maize, sunflower and vegetables in Tanzania. Agrics facilitates farmer access to inputs through the provision of bundles including certified seeds, fertilizers, agro-chemicals, poultry, mechanization, grain storage and extension services. Throughout the season, field officers provide extension support to ensure that the farmers get maximum return on their investment toward better yields. On top of their normal products, Agrics also offers the Geodatics tailor-made advise to their clients.

Communication

Agrics normally organizes farmers in groups in order to effectively provide support, help and feedback and access to inputs on credit. A group leader is to receive additional training and serve as central unit in communication amongst farmers in the group and Agrics field staff, who normally are hired for longer periods in order to provide continuity. Field staff provides training to farmer groups and feedback and support to the group leader. The group has a communal responsibility for payback of the loans. Provision of the packages and communication on input application with farmers normally is channelled via field staff and group leaders.

Communication in the project is built on the same model, farmers being addressed via field staff and group leaders. All farmers contacted by field workers were informed on project activities which included: extra support, tailor-made fertilizer advice calculated for their situation (considering field location, fertilizer history, manure availability and family conditions) plus specific fertilizer packages. An overview of collected information plus advice was presented in a farmer passport, individually prepared for each potential participant. Farmers joining the project were given the opportunity to order custom-made fertilizer bundles plus necessary credit to acquire them.

Mobile data management

The tailor made advise strongly depends on an accurate geolocation of farmer fields. Mobile data technology was used to collect farm and field data, during a so-called profiling interview, and for collection of additional socio-economic information in a pre- and post-season interview for farmers that were part of the monitoring and evaluation (M&E) programme. The "Jotbi" mobile phone app was developed for data-entry during profiling interviews, where farmers provided some general information including number of animals, crop yields and manure application. Additional plot (field) data were collected during a visit to the field and included a field quality assessment by the farmer, the location of the field and its perimeter. Geographic location of the field and walking distance from the homestead to the field were recorded using the GNSS receiver of the smartphone. These profiles were transferred to an analytical unit where they were combined with crop simulation models, soil data, market information, and satellite data. For the M&E programme, additional socio-economic data was collected during an pre-(or early)-season interview and an post-seasons interview to collect information about product experiences. A specific app was developed to facilitate data collection in Swahili and English languages. In some cases, e.g. when phones were not available, paper forms were used.

Tailored advice

The newly developed tailored service includes agronomic advice for maize and recommendations for optimum N, P and K supply that replace generic fertilizer recommendations. The advice is delivered to farmers via a farmer passport (on paper), and via community facilitators or field staff and group leaders, demonstrating agronomic practices in the field.

The nutrient advice was generated for a medium and a high input target yield, aiming for 50% and 80% of calculated rainfed yield potentials. These yield potentials were determined as median yields over >10 years with the generic crop growth model WOFOST, including parameters calibrated per the agro-ecological zone (van Ittersum and Cassman, 2013; Van Wart et al., 2013) and local soil depth estimates (Leenaars et al., 2015; 2018). Required weather data were derived from publically available ground stations (GSOD) in combination with NASA-Power and GIMMS/CHIRPS datasets, following procedures of Van Wart et al. (2015).

Yield estimates were further downscaled using adjustment factors based on comparisons of long-term normalised difference vegetation index data derived from MODIS (Huete et al., 2002; Running et al., 2004). Balanced nutrition was based on an inverted QUEFTS model (Janssen et al., 1990; Smaling and Janssen, 1993; Sattari et al., 2014), where soil fertility parameters were derived from local measurements (soil exchangeable K and P) in combination with means derived from African SOILGRIDS when reliable (pH and SOC) (Hengl et al., 2015; Hengl et al., 2017). In general, soil pH and K status are much higher in Northern Tanzania in comparison with acid and depleted soils of Western Kenya.

The study area

The tailored advice service was tested on farmer fields in 46 villages covering large parts of Western Kenya and the Sinyanga region of Northern Tanzania (Figure 1).

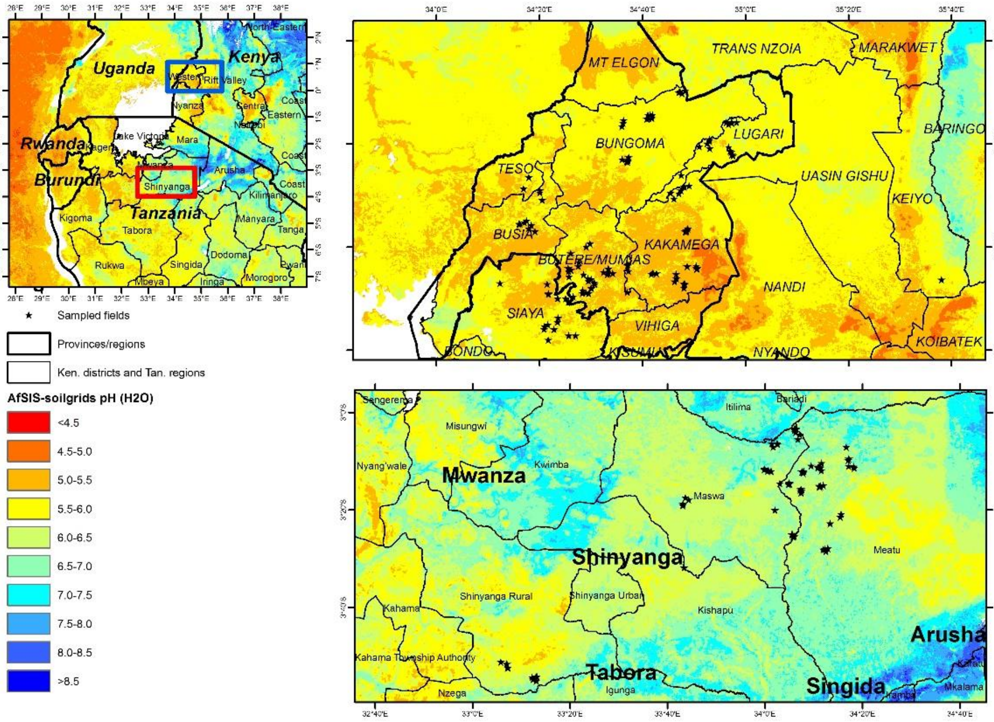

Figure 1. Locations of farmers in Tanzania and Western Kenia shown against a background of soil pH-H_2O.

These regions strongly differ in climatic conditions, Western Kenya has two more or less reliable growing seasons while Shinyanga has a single growing season with strongly variable rainfall and yields. Soils in Western Kenya are dominated by Nitisols, Ferralsols and Acrisols, mostly with a low pH values of around 4.5-5.5 and relatively poor soil fertility. Soils in Shinyanga are mostly sandy, including mostly Cambisols, and Planosols, and are derived from courser granitic parent material. Notably, soil K fertility is better when compared to Western Kenya and soil pH is much higher (Figure 1).

Evaluation of the service

An extensive monitoring and evaluation program was designed to evaluate the impact of project activities on crop yield and family income. Farm and field data were collected on selected farms. Farm selection was done using a stratified approach, to ensure that all regions, soil types and sufficient male and female farmers from all relevant regions were included. Soil types on selected farms are representative for the region and farmers from poor, median and slightly wealthier backgrounds were included. For each region served by Agrics, villages were selected with sufficient farmers using Agrics products to limit travel time. In each selected village, a group of farmers receiving Geodatics advice was compared with a control group that did not have access to any Agrics service. To this end, three pairs of farmers were selected with different socio-economic backgrounds within each village: each pair included a control and a Geodatics farmer of similar socio-economic status, living in similar conditions and are farming on similar soils.

A 10 x 10 m plot was marked on a field of all participating farms. Plot coordinates were recorded and a soil sample was taken before seeding. Applications of basal and top-dress fertilizer in plots was done under supervision of project staff to ensure that accurate amounts of fertilizer were applied. Farmers were free to use their own practices for crop management (weeding, insect control etc). At harvest, number of plants and cobs and shelled grain and stover weights were recorded in three sub-plots (3 x 4 m quadrats). Grain moisture contents were recorded with a moisture meter. Some farmers harvested before field teams arrived, more frequently control farmers than Geodatics farmers, and these plots were excluded from this study.

Information from M&E farmers was collected during two interviews, taken before and after the growing season. The pre-season interview collected data on household status, social-economic background of the family and on agronomic practices in the past. A digital questionnaire composed of 33 questions was used; completion took approximately 30 minutes per farmer. The questionnaire was implemented in a smartphone application (“Jotbi”) developed by Manobi Ltd.

The post-season survey included background questions adapted from the Rural Household Multi-Indicator Survey (RHoMIS), as presented by (Hammond et al., 2016). Questions covered food availability, household dietary diversity score (HDDS), household food insecurity access scale (HFIAS), the progress out of poverty index (PPI), and off-farm income. Additional questions were adapted from projects including “*Early impact survey N2Africa project*”, “*N2Africa Field book for focal adaptation trials*” (http://www.n2africa.org) and “*Humid Tropics Impact Lite*” (http://data.ilri.org/tools/dataset/impactlite), all being implemented by Wageningen University.

A section for customer experiences with the Geodatics products and relevance for farmer’s need was included at the end of the interview. Time spent on the post-season interview was approximately one hour and 30 minutes. Enumerators were recruited by Agrics, which also provided training for the use of the smartphone and app; enumerators did not have previous contact with the farmers before the interview. Results of the post-season interview are not yet available for the Kenyan 2017 long rain season as some farmers are expected to sell their crop in January-February of 2018, shortly before the next season.

Statistical analysis

Here, we only attempt to analyse impact of the service, without analysing participation (Pan, 2014). On all plots, recommended fertilizer was applied according to recommendations, simplifying the required analysis. Maize yield was measured to provide a first assessment of impact of the service. Crops yields vary between seasons and hence require comparisons between product user and control groups within a season. The pair-wise selection of "comparable" control farmers near Geodatics farmers reduced bias as much as possible. We checked for bias (e.g. Davis et al. 2012) by analysing differences in soil fertility indicators, number of animals and crop yields in previous seasons. A full comparison between the product user and control groups of co-variates that may affect yield is not included here (but will be done at a later stage). Improved yields can be attributed to Geodatics service when accounting for differences in location and agronomy between the two groups, e.g. soil fertility, manure use, weeding and use of pesticides. Differences in farmer-reported yields and soil fertility indicators (exchangeable K, P-Olson, soil organic carbon) between control and Geodatics farmers and male and female farmers were evaluated with a linear mixed effect model. Treatment and gender were included as fixed effect, while differences between locations were accounted for by including the village of the farmers as a mixed effect in the linear model.

Maize yields of farmers in the control and the tailored service groups were also evaluated by explained variance with a mixed model that identified fixed and random effects. Geodatics farmers used both basal and top-dress inorganic fertilizers, while control farmers strongly varied in what they used on their fields including inorganic and organic manures. Fixed effects included farmer group (control / tailored advice), sex of farmer, organic manure application, basal fertilizer use, top-dress fertilizer use and insecticide use. In a first analysis, results did not significantly differ between regions. The mixed effect included 'village' to account for random effects and differences between regions. The first analysis included a comparison of the two groups, testing for differences between male and female farmers. The second analysis evaluated all other variables. All analyses were done using R software (www.R-project.org), including the lme4 (Bates et al., 2015) and lmerTest packages (Kuznetsova et al., 2017), testing significance using the Satterthwaite III method.

Results

Mobile phone technology allowed integration of qualitative farmer-assessments of field quality, distance from the homestead with best available geodatasets to generate fertiliser advise at relatively low costs. However, smooth operation of the Jotbi app required basic skills and experience with mobile phones and trained casuals were used for this purpose. Delivery of advice to farmers was done via a farmer passport and field staff. We observed that proper training of field staff on how to use the app is key for further integration of services into the Agrics business. At present, the use of the app is primarily to support field staff to better service farmers.

Integration of the Geodatics service in the current business processes has had more implications than anticipated. Farmers need to be advised, but also adapted product packages need to be delivered to smallholders. Farmers need to be informed about the advantages, additional costs and investment requirements before the service can be formally offered. Delivery of farmer specific packages is logistically much more challenging than offering standard packages only, a reason to limit the number of fertilizer blends that were offered. For farmers, the decision is not just related to the question whether a new, innovative, product including advice will be purchased. The average amount of nutrients in the Geodatics package was typically higher than the standard blanket recommendation and thus required larger investments. Consequently, farmers had to indicate whether they would be willing to invest more and are able to make the required initial cash payments. Also, with increasing investments financial risks increased for farmers. But also for Agrics as credit supplier, the risk of defaulting increased. So, the integration of a new advice as part of their service has had more consequences than strictly providing improved fertilizer advice. It was observed that decisions on larger investment requirements are strongly influenced by the relationship between the farmer and Agrics field staff. It was anticipated that wider uptake of the service needs a clear demonstration of its value, for example in demonstration trials that were started as part of the Geodatics project from the short-rain season of 2017 onwards.

Evaluation of the service

The 62 male farmers had on average more cows, reported higher yields and had slightly better soil fertility indicators than the 64 female farmers in the study (Table 1). When accounting for differences between villages, the soil fertility in terms of organic carbon, P and K content of plots did not significantly differ between control and Geodatics farmers (Table 1). Both plant available P and K were below recommended levels (>10 mg/kg Olson P and 0.5 cmol/kg K) and indicate that soils should be responsive to P and K fertilization. Farmer-reported yields in the previous season were significantly (P<0.05) higher for male than for female farmers, but did not differ between control and Geodatics farmers.

Table 1. Means of predicted values of farmer-reported (FR) yields in Kenia in the previous season (short-rains in 2016) , soil organic carbon (SOC), P-Olson, and exchangeable K using mixed models with treatment and gender as fixed effects and villages as random effect. Different superscript letters within a column indicate significant differences (P<0.05) between factors treatment and gender, using a type III ANOVA with a Satterhwaite's method.

Treatment	Gender	N	Cows, #	FR yield, t/ha	SOC, %	P-Olsen, mg/kg	Exch.K, cmol/kg
Control	Female	21	1.0^a	2.9^a	1.9^a	7.1^a	0.39^a
	Male	23	1.4^a	4.0^b	2.1^a	6.7^a	0.36^a
Geodatics	Female	43	1.4^a	3.5^a	1.9^a	6.8^a	0.38^a
	Male	39	1.8^a	4.3^b	2.0^a	6.3^a	0.36^a

Average measured maize dry matter yield in 2017 was 3.4 tonne/ha (Table 2). These yields, equivalent to 4.0 t/ha at 15% moisture were slightly higher than the farmer-reported yields of 2016 for female farmers. There was no significant difference in yield between farmers in the control group and those who received the tailored advice. Many farmers in the control group also applied fertilizers, often in combination with use of insecticides, to control the Fall army worms that were encountered for the first year in Western Kenya. No difference was found in yields between male and female farmers.

Table 2. Estimates of effects on maize grain yield (tonne/ha) in the long rans season of 2017 in Kenia. The intercept estimate is based on female control farmers.

	Effect ± standard error	P-value
Intercept	3.4 ± 0.4	<0.001
Tailored advice	-0.5 ± 0.4	NS
Gender (Male farmers)	0.1 ± 0.6	NS
Tailored advice : Gender	0.4 ± 0.7	NS

Application of insecticide significantly affected crop yields, improving yields with 0.83 tonne/ha on average (Table 2). All farmers in the tailor-advice group were advised to apply insecticides when fall army worms were found in the field. Farmers in the control group also applied insecticides, often more frequently and at an earlier stage. Within the control group, use of insecticide resulted in yield differences of about 1.2 tonne/ha (not shown). This indicates that insecticide application was an important factor determining crop yield and applications were more effectively applied in the control group, probably because they were applying earlier and more often. The control group included fields that were manured with organic manure, these had on average slightly higher yields (P=0.052), likely reflecting historical practises and differentiating poor from good fields.

Table 2. Estimates of effects of management components on maize grain yield (tonne/ha).

	Estimated effect	P-value
Intercept, tonne/ha	2.41	<0.001
Manure application, tonne/kg applied	7.1E-4	0.01
Basal fertilizer, tonne/kg applied	5.9E-3	NS
Top-dress fertilizer, tonne/kg applied	1.7E-3	NS
Insecticide use	8.3E-1	0.02

Discussion and conclusion

Tailored nutrient advice services

Differences in soil fertility in SSA are very large, with strong spatio-temporal yield patterns and differences in the resilience of soil nutrient stocks (Njoroge et al., 2017). Given the current history of low and unbalanced nutrient applications in Africa, it is essential that applications are adjusted in order to at least include P and K and thereby prevent accelerated exhaustion of soil stocks. Analysis of single soil samples provides only limited information on plant available nutrients as the range of variation in relationships between plant available nutrients and yield responses are large (Njoroge et al., 2017).

The field-level advice that was generated combined best available information from field, farm, regional and spatial data sources. Farmers in the M&E program were given fertilizer packages which were optimal addressing existing soil fertility issues on their fields. This included tailor-made nutrient composition, fertilizer advice suited to existing soil nutrient status and additional technical support (e.g. training in Good Agricultural Practices).

The tailor-made advice and use of better fertilizer blends including N, P and K has likely helped farmers to improve yields in 2017. However, yields in the tailored advice group did not exceed those of the control group. As discussed above, the new invasive species Fall armyworm (*Spodoptera frugiperda)* (Goergen et al., 2016) had a major influence on yields. Midega et al. (2018) found that within the regions of Western Kenya up to 80-95% of maize plants in their monocrop plots in Western Kenya were infected in 2017. Yield reductions of 1.9-3.4 tonne/ha were observed compared to a push-pull system (Midega et al., 2018). This is 40-50% of observed yields and is similar to what was reported elsewhere. We found that application of insecticides had a strong influence on yield in contrast to applied fertilizer. Farmers in the control group applied insecticides earlier and more frequently, likely reducing damage by the Fall armyworm. The presence of Fall armyworms in the fields masked the effects of fertilizers applied.

A significant application of animal manure has been reported. Use of animal manure determines the soil fertility status of the fields but also the resource endowment of the farmer (Tittonell et al., 2008a; Tittonell and Giller, 2013; Tittonell et al., 2013), likely influencing insecticide use frequency in 2017.

The importance of agronomic guidance

Provision of agronomic information in Kenya and Tanzania largely depends on existing public extension services fed with information from national and regional research stations and universities. Farmers are served by extension officers on an individual basis. As there is limited knowledge of local soil conditions or nutrient management practices in the past, it is hard for extension workers to provide detailed fertilizer advice for individual farmers. Farmers in the Geodatics project have benefitted from tailor-made advice and customized fertilizer packages which are key to realize better returns on investments. An economic analysis of the results however remains to be done.

There is a significant difference between male and female farmers in SSA. Women often have lower accumulated resources, income and influence in decision-making bodies. Female households in western Kenya on average had fewer assets and earned lower incomes compared to male headed households. Further, they tend to have less access to productivity enhancing technologies - such as inorganic fertilisers and improved crop varieties (Tegemeo Institute, 2010). In contrast, Agrics is equally serving male and female farmers while the use of farm groups in discussing issues of input use and crop management may be expected to help female farmers overcome any bias in obtaining (new) information.

While rural education levels have improved substantially in the past, development of communications technology is bringing information much closer to smallholder farm households. Expansion of access to mobile phones, have been reported to reduce existing gender inequity in access to agricultural information, including market prices and ‘mobile banking’ (Garrity et al., 2012). This is confirmed by O’Donnel (2014). However, while lack of access to finance, training, and information services is limiting the choices of female farmers in day-to-day life, mobile technology could be used to bridge this gap.

Mobile technology

The credibility of information provided by mobile-phones to farmers require special attention (Stephens and Middleton, 2002; Burrell and Oreglia, 2015). In developing countries this requires local assistants at community level who can increase credibility of agricultural information, enhance field surveillance, and promptly provide integrated support (Fu and Akter, 2016; Nakato et al., 2016; Van Campenhout, 2017). Missing essential feedback and farmer’s perspective may result in failure when new products are employed (Stephens and Middleton, 2002). A participatory approach including interactive communication between researchers, extension agents, intermediaries in the local community and farmers is key for successful development of services and applications.

The variety of field management in a wide-range of farmers with different socioeconomic status hinders appropriate delivery of tailored-made services as messages need to be targeted to the client needs. For instance, low-income farmers would show no interest in a fee-based service; farmers with limited education need additional support from intermediaries by providing information through a voice message instead of text message. Younger and educated farmers are likely eager to receive agronomic support though mobile devices while old-age farmers need to invest in time to overcome technophobia and to familiarize themselves with new product (Kiiza and Pederson, 2012; Tadesse and Bahiigwa, 2015; Drafor, 2016).

Field staff observed that the use of mobile apps (Jotbi) in the project increased confidence and trust of farmers in comparison to standard (Agrics) approach based on paper forms. This effect may partly be explained by farmers responding to new (high tech) applications. Another part may be explained by additional information provided to the farmers, partly based on their data and fitting to their personal situation. An evaluation of this is being scheduled.

Conclusion

Mobile phone technology provides excellent means to collect and share data at field and farm levels, allowing advisors to link them with available scientific knowledge and satellite images and provide integrated advice tailored to specific conditions of smallholder farmers. The use of this approach allows development of improved nutrient management strategies that can address imbalance in current advice and provide better return on investment for farmers. In order to maximize the impact, fertilizer advice must be embedded within a complete agronomic package, including proper seeds and pest control measures. Most impacts are, however, expected in the long run. We conclude that proper embedding of services is very important, farmers are often illiterate, conservative and need local support to gain confidence in the products offered. Local support from extension officers or agronomic advisory services and demonstration remains important.

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