Optimization of Maize Variety Allocation
June 2020

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Executive Summary

Maize variety turnover is essential to take advantage of genetic gains generated by breeding efforts of the CGIAR and seed companies while ensuring farmers can adapt to climate change. One Acre Fund has launched a strategic plan to ensure that we are distributing newer varieties, selected to match site-specific environmental requirements and farmers' preferences. The project can be broadly divided in three steps:

1. Characterization of varieties currently in the market, and soon to be released - in total considering 140 varieties from 11 companies
2. Site characterization and definition of variety-attributes required at the site level - including current and projected demand, maize-variety market segmentation, climatic, landscape and soil limitations, prevalent pests and diseases, limitations on crop management practices, and farmers' preferences
3. Development of decision-support tools and distribution strategies to effectively match the variety description with the variety attribute requirements, at site and farmer levels.

In this document, we describe details of the project and share tools and documents generated along the process. We also describe the challenges we faced and next steps.

Full Project Report

Context

In 2020, One Acre Fund will distribute approximately 6,200 MT of hybrid maize seed across the seven East and Southern Africa countries (Tanzania, Kenya, Uganda, Rwanda, Burundi, Zambia, and Malawi). That seed is a mix of 25 different varieties from 11 companies, which each country program has selected to better fit their context (i.e., legislations, environments, and farmers' preferences). While that is a description of a successful intervention, there are also indicators showing that there is still large room for improvement.

The average age of the varieties One Acre Fund distribute across programs is 14 yrs (ranging from 2 - 32 yrs), while in an efficient seed system as the one developed in the USA is around 3 yrs (Brooks, 2009). Masuka et., al (2017) estimated that the average yearly genetic improvement of CIMMYT breeding programs in the region is approximately 1.1%. Moreover, climate change is expected to reduce yields of current varieties at a rate of 2% per decade, in part, because varieties become 'unadapted' to new environmental conditions. Considering that time from start of breeding a variety to release takes approximately 15 yrs, and that on average varieties are 14 yrs old (and even older for farmers not enrolled with One Acre Fund; Smale and Olawande, 2014), those varieties were tested in the early '90s, in a different climatic context. As such, fast variety turnover is essential to take advantage of genetic gains generated by breeding efforts of CIMMYT and seed companies, while ensuring farmers can adapt to climate change (Atlin et al., 2017; Porter et al., 2014; Cairns and Prasanna, 2018).

Increasing hybrid seed adoption and variety replacement rate are still major challenges in the region (Atlin et al., 2017). The long list of seed companies based in East and Southern Africa (FAO 2017), which in most cases have strong assistance from CIMMYT breeding programs resulted in several new varieties released in the last decade (Worku et al., 2020; Abate et al., 2017). New releases from CIMMYT and seed companies include varieties with key adaptation traits such as tolerance to prevalent diseases (e.g., MLN), and to most prevalent abiotic stresses (drought, and low N). The challenge that organizations like One Acre Fund and seed companies usually experience is the low adoption and replacement rates of

new varieties. Moreover, heterogeneous environments and farming practices, and specific attributes requested by farmers make changing varieties on catalogs risky.

Improving hybrid seed adoption and variety replacement rates would result in major increases in the impact of interventions related to maize seed distribution. Moreover, it would increase the impact of breeding efforts of organizations like CIMMYT, IITA and seed companies. In October 2019, One Acre Fund launched a strategic plan to ensure that we are distributing updated varieties, selected to match site specific environmental requirements and farmers' preferences. We expect the new tools, collaborations and processes developed in this project will result in an increase in impact per kg of seed distributed, and an increase on hybrid seed adoptions and replacement rates by farmers.

Project Objectives

1. Develop databases, tools and collaborations needed to improve characterization of maize varieties and the description of site-specific requirements of variety attributes.

2. Develop tools and intervention strategies to ensure that farmers receive the best variety according to their context; i.e., plot-level environment, management practices and farmers' preferences for specific attributes.

Approach

The project can be broadly divided in three steps; 1) Characterization of varieties currently in the market, and soon to be released, 2) Characterization of the varietal requirements at the site level, including environmental and management adaptations, and farmers's preferences, and 3) Develop tools and distribution strategies to effectively match the variety description with the variety requirements, at site and farmer levels.

Variety Characterization

A key aspect of the project was to build a database with extensive description of new, old and soon-to-be-released varieties. The attributes include all aspects of varieties that we found to be useful in at least one of our areas of One Acre Fund operations, and also traits frequently described by seed company catalogs, or mentioned by farmers in different published studies.

Attributes

1. Average yield, yield stability and adaptability.

To combine yield performance data from different sources we use the concept of "relative yield" (RY), where performance of each variety is expressed as relative to the overall trial average (environmental index; EI). This allows us to compare varieties evaluated in different trials, conducted by different organizations and even in different countries. We also characterize varieties by how they perforform in environments of different quality, through an stability analysis; slope of a linear regression of the RY of a variety as a function of the EI (Finlay and Wilkinson, 1963). Some varieties are relatively good performers in poor environments (e.g. drought, late planting, low fertilizer, poor general management of the crop, etc), others perform well in high potential environments (e.g., good season, high fertilizer, good crop management) and there are exceptional varieties that perform well in good and bad environments (varieties that can do this are described

as having high stability). We also consider specific yield adaptations to biotic stresses, such as drought and low nitrogen tolerance, and adaptation to altitude.

2. Development rate

After yield, this is the most considered trait by farmers when selecting varieties (Worku et al., 2020; Ajambo et al., 2017; De Groote and Siambi, 2002). In general, the longer the cycle of the variety, the better the yield in good environmental conditions (high yield potential), but the worst in bad conditions (low stability), as shown in a simulation study conducted in the region by Seyoum et al. (2017). So, it's critical to find a balanced cycle length that can ensure that most of the years the variety will complete their cycle within the rainy season and is long enough to have good yields in good seasons. To characterize the development rate of the varieties we collect data of time (days and when available in growing degree days) required to flower and to reach physiological maturity.

3. Disease tolerance

Distribution of varieties susceptible to prevalent diseases could result in a significant negative impact for farmers, conflicts with local governments and losing trust from farmers. As such, we collect as much information as possible regarding tolerance and /or susceptibility of varieties to diseases that are prevalent in at least one of our areas of operations.

4. Other attributes related to farmers's preferences

There are several attributes beyond yield and maturity rates that farmers consider important when selecting varieties. These attributes change from site to site and farmer to farmer, and in many cases are main adoption barriers. There is large bibliography on attributes considered by farmers in different countries, and One Acre Fund also collected this information on some of our programs (see table in "Sites Characterization" section). The following are attributes we identified as important in at least one of the regions where we operate, and we try to collect for available varieties; grain texture, cob size, grain color, grain taste, cobs per plant, droopy vs. upright cobs at harvest, husk cover, stay-green, plant and cob height and lodging susceptibility.

5. Adoption/ preference data

Information of farmers's preference for specific varieties is not always available. Moreover, this information is usually site-specific and not extrapolable. However, One Acre Fund records this information in on-farm and on-station trials, and in some cases on core-program surveys.

6. List of countries where varieties are or will soon be released, and year of first release.

The list of released varieties differ significantly among countries, and having a clear map of what varieties are available at each location is critical for planning our research pipeline and the distribution strategies. In some cases, One Acre Fund can work together with seed companies to advocate for release of specific varieties in specific countries of interest.

Data sources

For the characterization of maize varieties we combine information from different sources. These include One Acre Fund's maize variety research pipeline, publications, seed company online catalogs, CIMMYT variety release documents, and direct One Acre Fund- Seed company communications.

1. One Acre Fund research pipeline.

One Acre Fund currently has 7 research stations distributed in different countries and covering different maize mega environments. We also perform on-farm trials, as described below. On station trials we closely aligned with CIMMYT

protocols (CIMMYT 1985) and we also adapted the protocols for on-farm trials; e.g., we reduced the complexity of trial setup, and the number of variables to record **(see "One Acre Fund Trial Protocols" attached)**.

Maize Variety Research Pipeline at One Acre Fund	
On-Station	We evaluate varieties under highly controlled conditions, which allows us to collect high-quality data on yield and on traits with high heritability (i.e., low genotype x environment interaction). For example, we record development rate, plant and ear height, and disease tolerance/ susceptibility, among others. In some cases, we also expose varieties to a range of environments within the same station-season, using contrasting management practices (e.g., late planting to simulate early rains cessation, low fertilizer, extra-low densities, and optimum conditions). On-station trials limitations: 1. They cover a small sample of environments 2. Generally, crops are usually grown under better conditions than what they usually experience in farmers' fields. 3. We can't effectively study potential restrictions to adoption by farmers (i.e., farmers' preferences).
On-Farm	Participatory trials overcome some of the limitations of station trials. These trials cover a wide range of environments and socio-cultural factors and are more representative of "actual farmer" conditions. As such, it is better to predict the ranking and relative performance of varieties, and we can also get a good sense of farmers' preferences and potential adoption. Unfortunately, the cost of evaluation per variety is significantly higher, and the number of varieties we can evaluate side-by-side is limited (5-6 as maximum). In the on-farm trials, we focus on yield, yield stability, and adaptability, response to biotic and abiotic stresses, and we make a special focus on farmers' preferences.

2. Publications and CIMMYT variety release documents

CIMMYT periodically publishes regional trial results, which include new variety releases and usually include 4-6 local checks, which are usually among the ones One Acre Fund distribute, or consider for distribution. This is a great source of information as trials are conducted in a wide range of environments and they record several key attributes for each variety. There are also several publications from different universities and research organizations reporting comparative trials of maize variety.

3. Seed company catalogs.

From these catalogs we mainly extract information on grain texture, maturity rate, general adaptations of the varieties (e.g., altitude and hydric regimes), and specific tolerance to biotic and abiotic stresses. In some cases, catalogs also describe particular characteristics of the varieties; e.g., forage-stover productivity and husk cover.

4. One Acre Fund-Seed company collaborations and direct communications.

Seed companies know to the detail the characteristics of their varieties and clearly understand their specific adaptations, and on what environments they can and can't express their advantages. A key aspect of this project is to improve the

communication channels with seed companies. One Acre Fund provides information on site-specific variety requirements for the areas where we operate, while seed companies provide detailed information of the best varieties currently in the market, and for the ones they have in the development pipeline. One Acre Fund also provides information about market demand for each region where we operate, such as; i) total demand and proportion of variety type by region, ii) common characteristics of most popular varieties, iii) future demand projections. Data to exchange would be done yearly, using a spreadsheet divided into three categories **(see "Seed Company Collaboration" spreadsheet template attached)**. The information that One Acre Fund requests to seed companies includes:

- *Variety performance on trials.* One Acre Fund and the seed company exchange information on varieties performance on field trials.

- *Catalog description*. Here, companies describe varieties for all the parameters that One Acre Fund considers critical for allocation across different areas of operation. Those parameters were identified from our own experiences and from literature, and could be grouped in 3 buckets: 1) General environment adaptation (e.g., altitude, mega environments), 2) Specific environmental adaptation (e.g., average environment yield, biotic and abiotic stress), and 3) Farmers' preference related attributes (e.g., grain texture, husk cover, stay-green).

- *Allocation Recommendations.* Here companies recommend varieties for each specific context; they allocate each variety to the locations where they think will perform well and are expected to be adopted by farmers considering all the attributes. The context is a combination of country, general environment description, specific environmental description and parameters that are critical for farmers' adoption. One Acre Fund provides the context information for each allocation site and companies would ideally recommend the best 2 varieties already on the market, and 2 varieties soon to be released.

Sites Characterization

Clear understanding of the varietal requirements of farmers and environments on each site is critical for a correct allocation and marketing of varieties. We use this information on our distribution planning and it's also information that seed companies require to do recommendations for us, specially for areas where they have not much experience (e.g., Zamseed, a seed company located in Zambia and about to release varieties in Rwanda). One Acre Fund did characterizations of the sites where we operate by gathering information for different parameters at the country- maize mega environment combination.

See below a list of the information we collected and where we obtain it from:

- *Maize mega-environment.* We use maize mega-environment maps (CIMMYT. 2004) to classify each site within each country. In countries where these maps do not represent the maize environments correctly, we also use local agro ecological maps (e.g., Rwanda and Burundi).

- *General environment description.* These are climatic variables that define the mega environments class; i.e., temperature and hydric regime.

- *Main diseases*; insect pests, and presence of striga. This data has been collected from extensive bibliographic reviews and from One Acre Fund's experience.

- *Main abiotic stresses*. These mainly include drought and soil fertility limitations, and is information that has also been collected from extensive bibliographic reviews and from One Acre Fund's experience and trial reports.

- *Management limitations.* This information has been mainly obtained from One Acre Fund experience and surveys, and include, for example planting time, seeding density, soil fertility and weed management.

- *Farmer's preferences*. We collected this information from One Acre Fund surveys and maize variety trials, and from an extensive bibliographic review (see table below). This parameter is as critical as challenging; it changes from country to country, among neighbouring farmers and even for the same famer it can change for different plots and along the time. So it's important to keep recording this information to increase the confidence and to capture the evolution of farmers preferences.

- *Popular hybrids. P*opular varieties are a good reference to farmers's preferences and to variety-type adaptation. We collect this mainly from bibliografic reviews (see table below), and in countries where we have longer experience of offerening different varieties, form our own surveys.

References to farmers preferences (x) and/or popular varieties (o)	Kenya	Tanzania	Malawi	Zambia	Burundi	Uganda	Rwanda
Worku et al., 2020	x	x				x	x
Obaa et al., 2005						x o	
Ajambo et al., 2017						x o	
Kakuru, 2012						x o	
Abate et al., 2017	o	o	o	o		o	
Ntega-Nanyeeya et al., 1977						x o	
Wekesa et al., 2003	x o						
Ouma et al., 2002	x o						
Wang et al., 2017	x						
Odendo et al., 2001	x o						
Salasya et al., 2007	x						
Ouma et al., 2011	x o						
Ouma and De Grote, 2011	x o						
Andersson et al., 2018	o						
FAO, 2014	o						
Nyaligwa et al., 2017		x o					
Ndakidem, 2017		o					
Mutanyagwa, 2017		o					
Westengen et al., 2014		x o					
AGRA, 2016		x					
Lymo et al., 2014		x o					
Waldman et al., 2017				x o			
De Groote et al., 2011				x o			
Mubanga, 2014				o			
Mukanga et al., 2010				o			

Kalinda et al., 2013				x			
Lunduka et al., 2012			x				
Audet-Bélanger et al., 2016			x o				
Katengeza et al., 2012			x o				
Enzama, 2016			x				
Sutcliffe, 2014			x o				

Tools and processes developed

The last step was to develop tools that can be used to effectively select varieties that will best perform in terms of yield and stability, and that will also align with farmers' preferences. We also developed tools and documents to guide and re-design the research pipeline to increase efficiency of the evaluation process.

Tools to support variety selection for distribution

1. Databases.

We created two databases where we collect trial results from our own trials, from bibliography and what seed companies shared with us. One database contains all One Acre Fund data at plot level (currently > 10,000 data points created in > 110 on-farm and on-station trials, in 6 different countries); which we mainly use for yield stability analysis (Finlay and Wilkinson, 1993). Eventually this database can be used for other kinds of adaptability evaluations and to better understand general concepts of maize variety response to environment and management. This database includes several parameters and would also be very valuable to calibrate and validate crop models. This database could be shared upon request.

The second database is trial-average data, where we pooled One Acre Fund data, bibliography data and data shared by seed companies. This database includes more trials and varieties, and is from where we pool most of the yield, development and pest-disease parameters to make variety decisions. This database currently consists of 1500 data points (each representing the average of one variety in one trial), from 240 reports (77 from CIMMYT, 140 from One Acre Fund and 23 from other publications or from seed company results). This database contains information shared by companies that can not be disclosed, but upor request we could share a version where we do not include data shared by the companies.

2. Semi-automatic variety selector tool

We created an excel spreadsheet where we pull together all available information for each variety. Using simple excel formulas, the tool describes performance and attributes of each variety on each specific site (Country- Mega Environment combination). This is a powerful tool that allows us to compare, side by side the performance of all available varieties, with a long list of attributes so we can select varieties that better match site specific requirements. This tool contains information shared by companies that can not be disclosed, but we attach an example version for one country, where we eliminate all data shared by the companies **(see attached as "Variety Selection and Allocation Tool").**

Tools to increase efficacy and efficiency of our variety research pipeline

1. Unique-protocols guide

We developed a guide for maize variety trials design and protocols for execution (both on-station and on-farm), ensuring we aling as much as possible with CIMMYT guidelines used in regional Multi-environment trials (CIMMYT, 2014). This way

we aim at making simpler and more effective data pooling (which comes from different sources), and ultimately increase the power of the analysis. The guide also includes basic concepts of experimental design and on error control, to increase the quality of our trials. We also added protocols to ensure we have a good capture of farmers's preferences. **(seed the "One Acre Fund Trial Protocols" attached).**

2. Central pipeline design

We constructed a tool that helps us to prioritize varieties to evaluate on our research pipeline and how to better design the allocation of varieties across our stations. This tool guides the user through a process to score each variety on a "priority value". It then guides the user on how to allocate those varieties to different research stations, according to the priority score, and the variety adaptation and the mega environment description of the stations. The parameters to score priority for evaluation on each variety include, among others; year of release, database size, seed company recommendations, N of countries where it's released (or will soon be), and relevance of the adaptation type for One Acre Fund farmers.

Progress, Results, and Challenges

Tools previously described were developed on time for coming season recommendations in four One Acre Fund countries of operations. Moreover, databases were completed enough to make satisfactory recommendations and to support the design of the maize variety research pipeline. Below we describe and share results of those recommendations and describe challenges we face in the process.

Tools used for 2020 recommendations

Tools developed in the project were successfully used to select and recommend varieties for One Acre Fund distribution in 2020-21 seasons in Rwanda, Tanzania, Zambia and Burundi programs. In total we considered 140 varieties, from 11 companies. The format of the varieties-recommendations we reached were modulated by the distribution strategy of each country, and the external restrictions (e.g., variety release list, seed sourcing limitations). In some cases the recommendation includes one variety per site (and one or two backups) like in Rwanda, and in other cases farmers are offered a catalog where to select varieties from. In Tanzania and Zambia, for example, the recommendation includes 7-8 varieties, each with a specific marketing message with which field officers can guide farmers to select the best variety according to the environmental and management considerations of their plot **(see "2021LR_RW/TZ/ZA" attached).**

Along the process of selecting varieties for core-recommendations we identified varieties for which we had no enough data to confidently recommend at scale. Those varieties are mainly new releases, soon-to-be releases, varieties that are popular or recommended by the seed companies, and/or there is any other evidence suggesting that are varieties we should consider. We identified 68 varieties for which we labeled as "more data needed" and followed a strategic process to decide what varieties to prioritize for more trials, considering our limited capacity. The process consists of scoring varieties according to parameters that would indicate promising performance (e.g., new releases, recommended by seed companies, tolerant to prevalent diseases and/or biotic stresses, aligning with farmers' and environment requirements) and adapted to regions that demand new varieties (e.g., areas where we are distributing old or low adopted varieties, or areas of expansion). During the 2020-21 seasons we are planning to evaluate a list of 48 varieties, in 1-3 stations each, along the 7 One Acre Fund-research stations (4 of them with 2 seasons per year).

We also shared the new protocols with each country R&D team, and are currently on conversations and attending followup calls for clarifications and adaptation of protocols, when needed. We aim at a full alignment on the new protocols by 2021-22 season trials.

Challenges

Replacement of popular varieties

In most of our programs we have been distributing popular and highly adopted varieties for several seasons, and teams see high risk of replacing them, even if we identified better options (for example Pan 691 in Tanzania, a 20 years old variety). The risk of variety replacement could, for example involve reduction in farmers adoption of hybrid seed, farmer's and local government complaints, reduction in farmers enrollment with One Acre Fund, and/or failures in new seed sourcing channels. This is an issue that seed companies also face in several regions (e.g., Kenya Seed Company with variety H624 D in Kenya, personal communication, or SeedCo with SC 513, released in 1999). We envision that improving our variety selection process and ensuring that we factor farmers preferences in this process will, in the long term, facilitate farmers' variety exchange speed. However, we are also supporting teams on reviewing and updating the distribution systems to help them and farmers reduce the risk of new variety adoption. We prepared a guide for our teams on how to balance complexity and potential impact of different alternative systems. We will support them on strategies to move towards an ideal system, where farmers can choose varieties from a 4-8 varieties catalog, and select more than one. This way, farmers can be encouraged to "trial" new varieties with minimal risk **(see attached the document to guide decision making on variety distribution systems; "Variety Distribution Systems").**

Communication with seed companies

Collaborations with seed companies is a key pillar on this project, their support would make the variety selection process more effective and efficient. We mapped a list of 27 seed companies in the region (see table below), which are offering at least 1 promising variety. Six are relatively large companies offering several varieties and covering several countries and mega environments (Corteva, Wester Seed Company, SeedCo, Kenya Seed, Syngenta, Bayer). There is intermediate companies, with several varieties, but localized in one or two countries (e.g., Zamseed, East Africa Seed, Uyole), and there also smaller companies, usually commercialising CIMMYT varieties, in one county (e.g., Dryland, Lake, Demeter).

During the last 6 months, we have been contacting and meeting with several seed companies in the region and most of them agreed to share with us the requested information. The communication started well but has been blocked for a while and only 3 (EAS, Zamseed and Dryland) reach the end goal of sharing the data. We are redesigning our communication strategy to ensure that by the next cycle of variety decision we can get information from all promising varieties in the region, and they are all included in our selection process. See below a list of the mapped companies with at least one promising variety released in at least one of the countries where One Acre Fund operates.

Company	Countries where operate	Company	Countries where operate
EAS	KE, soon in TZ, RW, UG, ZA	Elgon Kenya	KE
KSC	KE, RW, BU	Capstone Seed	MW, ZA
WSC	KE, RW	Demeter Seed	MW, ZA, TZ
SeedCo	All countries	Zamseed	ZA, TZ, soon in RW, MW, KE, UG and BU
Corteva	All countries	Klein Karoo	ZA, MW
Bayer	All countries	Lake	ZA

Syngenta	ZA, TZ, KE	Afri Seed	ZA
Naseco	UG, RW, BU	ASA	TZ
Pearl Seed LTD	UG	Meru Agro	TZ
FICA Seeds	UG, TZ	Animata	TZ
Victoria Seeds	UG, RW	Zenobia	TZ
Ecuator Seed	UG	Krishna Seed CO	TZ
Dryland Seed	KE, soon in RW, TZ, UG	RHM	RW
FreshCo	UG		

Maize mega environments update

Hybrid maize seed distribution is among the most impactful interventions to support smallholder farmers in Sub Saharan Africa (Smale and Jayne 2003; Kassie et al., 2014; Fisher et al., 2015; Abate et al., 2017). The impact, however, is conditioned to a correct allocation of varieties; that is, the varieties should be able to express their potential under the environmental conditions they will be exposed to. On this project we have been relying on CIMMYT developed maps (CIMMYT 2004). Those maps, however, are not specific enough for an accurate maize seed distribution. They were designed for breeders' needs, such as defining breeding strategies and key locations for regional variety testing (Hartkamp et al., 2000, CIMMYT 2004, Bellon et al., 2005). The main limitations of these maps arise from the fact that they were designed using a world-wide approach, and thus lack the level of specificity and granularity required by One Acre Fund and seed companies. Moreover, all of them were designed to map the main season, while in several regions there is a second season when maize is also grown.

An example of the limitations of the current CIMMYT-ME maps on One Acre Fund model of maize seed distribution occurs in Rwanda. From our experience and local government understanding, the boundaries for high altitude/ transitional and mid-low altitude are not precise in CIMMYT-ME maps (CIMMYT, 2004). See in the figure below, the West side of the country, bordering the Kivu Lake (West sides of Rutsiro, Karongi, Nyamasheke); from our experience, they are all upper-mid and mid-altitude locations and distribution of high altitude varieties would be a considerable mistake. This is captured quite well by the local AEZ classification (right); however, it is not well captured by CIMMYT map (left). Similarly, Kirehe District (South East corner of the country) is among the driest areas of the country, while according to CIMMYT-ME, it's classified as upper-mid altitude wet.
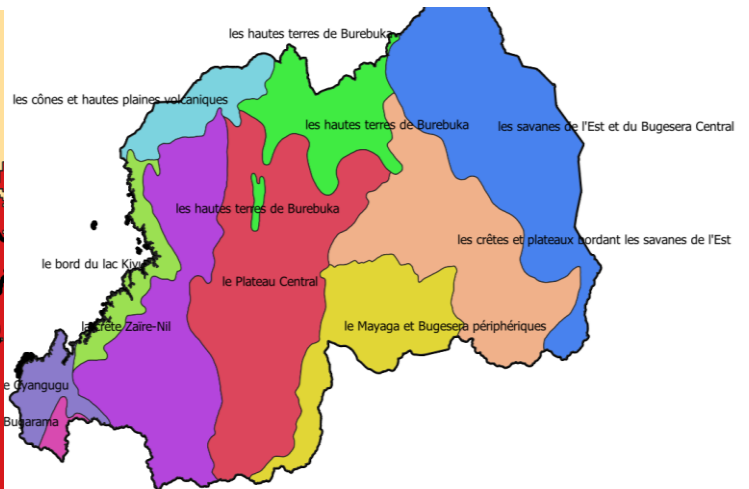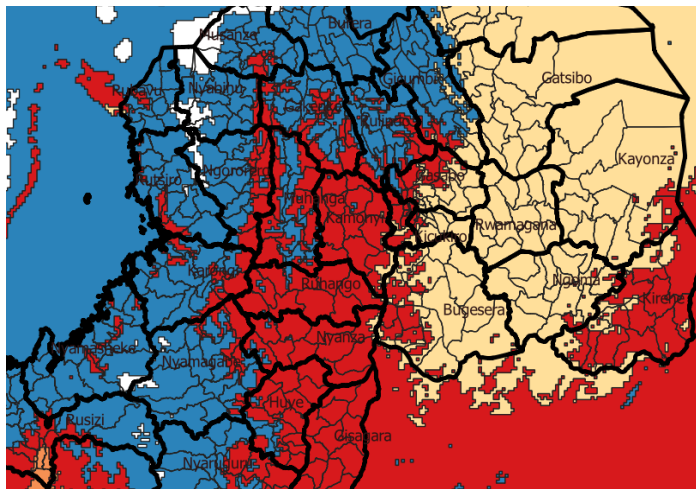
Left- Maize ME; CIMMYT. (2004); blue is highland, red in mid-low wet, yellow is mid-low dry. Right- Agroecological maps of Rwanda (Verdoodt and Van Ranst, 2003). See the Western side of the country, the AEZ called Lac Kivu; from our experience, and government and farmers preference is mid to transitional area.

Using local Agro-Ecological maps is useful in some countries (Rwanda and Kenya), however, this approach limits our ability to globally integrate our research pipelines, the research conducted by other organizations, and companies feedback into more effective and efficient variety evaluation and allocation processes. Moreover, in other countries (such as Uganda, Zambia or Malawi) local AEZ maps are not specific enough to maize. Finally, for all countries of operations, the climatic records used for all AEZs (and most ME) currently available are > 20 years old, with expected changes in climatic parameters in the last two decades (Omoyo, et al., 2015; Mumo et al., 2018).

Next Steps

The process and tools developed to improve our maize variety selection processes will be continually updated and improved. Variety decisions are distributed along the year for One Acre Fund, as we operate in several contrasting environments, where maize seasons differ, but we identified two times of the year when most decisions are done. Updates will be done right before those periods; in August and January of each year.

Database updates and tools improvement

Each season, before the process of variety recommendations start, our databases and tools will be revised and updated. We will include newly generated data on the One Acre Fund pipeline and surveys, published data on variety performance and information shared by seed companies. As our databases become more complete, we will also evaluate the inclusion of new variables into our decision process. Also, there is room for an increase in automatization (e.g., construction of shiny apps).

Communication with seed companies and CIMMYT

We are redesigning our communication strategy, involving local R&D teams and global sourcing teams to ensure we reach fruitful collaborations with all seed companies in the region. By January 2021 we target to have shared requested information from all six major companies and from >50% of the 21 medium and small companies. We think that all companies have promising varieties and tagert to have started communications with all of them by the end of 2020. For

the information about varieties from smaller companies (which are mostly CIMMYT releases) we are also directly approaching CIMMYT to get their support with information on their varieties, which are being commercialized by smaller companies (e.g., Equator Seed, Dryland Seed, Meru Agro).

Maize mega environments update

One Acre Fund has designed a protocol to develop an updated version of CIMMYT-ME maps, which is based on temperature, altitude and seasonal water balance, and is specific to East and Southern Africa. In the process of construction, we would align the limits and thresholds for the classification criteria with local knowledge from One Acre Fund, farmers and seed companies. These maps would be key for One Acre Fund, seed companies, and others involved in maize seed development, multiplication and distribution chain to better evaluate and allocate maize varieties to ensure that they can express their full potential. One Acre Fund is currently looking for partners to engage on such a project **(see attached a description of the project and proposed protocols for maps improvement; "Updating ME-Maps")**.

	Description of attached documents
One Acre Fund Trial Protocols	- Detailed trial protocols for One Acre Fund-R&D teams. These were designed to align with CIMMYT protocols. - Includes both on-farm and on-station trials
Seed Company Collaboration	- This spreadsheet describes the information that One Acre Fund requested to Seed companies. - It includes trial data, attributes description of the varieties and we also request companies to do specific allocation recommendations of their varieties. - This is the same template we use to share our trial data with them
Variety Selection And Allocation Tool	- This is the core" Mz Variety Decisions tool", where we centralize all information available for each variety and the description of Country-Mega Environment requirements. - The tool allows us to effectively match a variety description with environment+farmers requirements, at the Country-Megaenvironment level. - This database contains data shared by seed companies that can not be disclosed. However, upon requests and under specific conditions, complete tools could be shared.
2021A Recomendation_RW /TZ/ZA	This spreadsheet describes the recommendations we reached for 2020/21 recommendations in three countries of operation.

Variety Distribution Systems	• This document was developed to support the country- One Acre Fund teams to evaluate and plan improvements on their seed variety distribution systems. • The goal is to move towards an ideal system where farmers can choose >1 variety from a 4-6 variety-catalog.
Updating ME-Maps	• Accurate Mega Environment maps is a key aspect for an efficient and effective maize variety evaluation and allocation process. • While One Acre Fund has been relying on old CIMMYT maps, we identified some limitations on them. • One Acre Fund is working, in collaboration with U. of Reading, to update and upgrade ME maps to increase granularity and specificity to East and South Africa.

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