Rotation Crops for Cereal Farmers

Compatibility, Rotation Benefits and Market Potential

Kenya

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AGVENTURE SUSTAINABLE FARMING

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Introduction

Farming systems in many regions of East Africa have traditionally focused on the continuous mono-cropping of cereals. Over time, this has had adverse effects on soil quality and led to the build-up of pest and disease populations and, as a consequence, to reduced yields. To mitigate and reverse this trend, Agventure Ltd. and the Syngenta Foundation for Sustainable Agriculture aim to introduce new rotation crops. Our aim is to diversify farming systems and thus make them more resilient. Agventure Ltd. has already successfully established canola and pulse rotations with grain farmers in Kenya's Rift Valley; the Syngenta Foundation works, for example, on maize seed breeding through its Seeds2B program.

The *Rotation Crops for Cereal Farmers* study aimed to assess agronomic and market potential, ensuring that Kenyan farmers have selling options for crops grown in diversified production systems. The study focused on small grain cereal production systems, using maize as a bench mark. It enables us to:

- Identify compatibility between existing benchmark (cereal base) crop and rotation crop options;
- Identify rotation crop benefits (soil, disease, and pest control);
- Identify the rotation crop market potential and path to market;
- Present a basic business case for each rotation crop.

This report is the output. It provides a tool with which to assess rotation crop potential and inform future investment opportunities. The report presents the process through which the Rotation Crop Assessment Tool was developed and tested for field peas, green grams, oats, quinoa and soya. It concludes with recommendations for further research, refinement of the tool, and applications for other benchmark cereal crops and country contexts.

Background

Agventure Ltd

Agventure (www.agvke.com/) is a commercial cooperative of large-scale farms in Kenya. It focuses on improving yield in dryland farming through rotation crops and moisture conservation strategies such as 'Zero Till' farming. Agventure has been working on rotation crops since 2010. As a central contribution to the zero-tillage approach, Agventure has trialled (both growing and selling) 18 different rotation crops. Eight have proven successful in the climatic conditions of Meru and Nakuru County, Kenya. These are wheat, barley, maize, sorghum, sunflower, canola, field peas and beans. The latter include red kidney beans, mung beans (green grams), faba beans, chickpeas, kabuli and desi.

Existing Agventure production activities

The production and marketing of the eight crops is organized into four main business units:

- Purchasing of inputs (chemicals and fertilisers)
- Packaging and sales of unprocessed crops (wheat, maize, barley, beans and sorghum)
- Sale of partly processed crops (packing and selling green peas for both local and export markets).
- Oilseed processing:
    - Cold-pressed canola oil from a crushing unit in Timau: *Pure Mountain Farm Oil* is a range of cold-pressed flavoured oils and salad dressings sold in Agventure's own retail outlets, as well as supermarkets.
    - Multi-stage hot-pressed unrefined canola and sunflower oil from a crushing unit in Nakuru: Agventure markets bulk canola oil from its Nakuru factory. The largest customer is Unilever; its demand of 4000 tons per year exceeds Agventure's current supply capacity. To boost the production of canola in Kenya and thereby meet the growing local demand, Agventure has set up partnerships with East African Maltings, Bayer and Unilever,
    - Canola and sunflower feed cake: High-protein canola meal is currently sold to the dairy industry, where its excellent digestibility enables outstanding effects on milk yield and animal health.

Syngenta Foundation for Sustainable Agriculture

The Syngenta Foundation (www.syngentafoundation.org) focuses on smallholders, productivity and markets. It aims to help small farmers become more professional growers. The Foundation does this by extending science-based know-how, facilitating access to quality inputs, and linking smallholders to markets in profitable ways. This adds value for rural communities, and sustainably improves food security.

Methodology

The *Rotation Crops for Cereal Farmers* study was conducted by a team of consultants working in collaboration with Agventure Ltd. and the Syngenta Foundation for Sustainable Agriculture. Detailed profiles of the project team members are listed in Annex 1.

Process

Brainstorming

The study began with a series of brainstorming session. These were designed to shortlist high-potential rotation crop options for cereal farmers in Kenya, based on practical Agventure knowledge and experience. The brainstorming led to identification of many complex factors affecting potential for rotation crops. These factors were organized into a matrix, originally envisioned as a tool for agribusinesses and farmers to identify optimal rotation crops through a comparable scoring system. The main outcome of the brainstorming was selection of five rotation crops for initial study: field peas, green grams, oats, quinoa and soya.

Matrix: Design, Development and Refinement

Matrix Design

The next step was design and development of a matrix tool. The first iteration produced a complex list of dozens of factors that could determine the suitability and compatibility of a rotation crop with a cereal base crop on medium to large farms.

Matrix design began with maize as a cereal baseline against which to score rotation crop compatibility and market potential. The first guiding question was: "If a farmer is growing maize in Kenya, which rotation crops would be the most compatible options?" Among those options with agronomic compatibility, the second question was: "Which would present the best rotation benefits and market potential?"

Matrix Development

To answer these questions for field peas, green grams, oats, quinoa and soya against maize (benchmark cereal base crop), the consultants organized a scoring system based on three high-level categories:

- **Agronomy** – how compatible is the rotation crop with the cereal base in terms of machinery required, geography and topography, sensitivity to pests and disease, and crop cycles?
- **Rotation benefits** – what benefits does the rotation crop offer, such as nitrogen fixation, soil fertility, weed control, disease and pest control, reduced soil erosion, etc.?
- **Market potential** – how strong is the market for the rotation crop? (Looking at factors such as global and local demand, strength of competition, pricing, potential for value addition, regulation and government support, market access, etc.)

Desk research established the cereal baseline, using maize as a benchmark and looking at the agronomic conditions required for this crop's growth in Kenya, and potential for rotation benefits to farmers growing it. To begin populating and testing the matrix design, research then followed into the rotation crop factors listed above.

Matrix Refinement

Testing the five rotation crops against a maize benchmark identified several categories for which the tool needed to be refined:

1. Technicality of agronomy;
2. Context (farm location and size, country, political and economic situation);
3. Data availability, variability, quality and consistency;
4. Tailoring practical tools to different decision-makers (Agventure, investors, donors, agribusiness, smallholders and large farmers).

Agronomy

The initial approach to the matrix design was to use as much objective scoring as possible. Each agronomic factor by which to assess the rotation crops was defined with a unit, metric, baseline benchmark and detailed scoring criteria. However, it soon became clear that this approach was too prescriptive. Many factors were found to be extremely complex and

context-specific. For example, optimum growing ranges for maize may overlap with those for a rotation crop. However, adapted varieties could help extend production at towards the beginning and end of the season, which might lead to more flexibility in cropping cycles. This affects agronomic variables such as temperature tolerance, pH, soil moisture, and others.

Context

Each of the factors also had varying levels of importance in determining rotation crop potential. A complex weighting system was required to compare scores effectively across categories and crops. Furthermore, the importance of some factors varies between farm sizes, countries and crops.

Through the next set of consultations between the project team, Agventure and the Syngenta Foundation, it became clear that the key contextual variables to consider include:

- Farm size
- Geography / farm location
- National regulation, infrastructure, and economy
- Crop varieties
- Crop potential relative to other rotation crop options

Farm size and location are especially important when considering compatibility between a cereal crop and rotation crop option. Is machinery required to plant, harvest or store a rotation crop that is different from what is used for the base crop? A small-scale farmer may conduct all of these processes by hand, while a larger-scale farmer would use various types of machinery and storage facilities. Farmers with access to different resources also require a different approach to pest, disease and weed control. Additionally, farm size, access to inputs and farming practices affect potential yields and therefore profits, determining the attractiveness of the rotation crop business case differently for each farmer. Soil and rainfall are furthermore quite specific to farm location, and many crop varieties can grow in a variety of soil condition permutations.

Data Quality

Challenges also arose related to data quality. Establishing an objective rating tool requires specific, consistent data. Agronomic information on crop husbandry in East Africa is available from various sources, but these often provide inconsistent data and recommendations. Data remain split across various producers and systems. Data on market size, consumer demand, pricing and crop production are difficult to access, and inconsistent across sources. Data on off-takers and processing infrastructure are also generally quite limited.

Tools for Different Decision-makers

It became clear that the complexity of the matrix would make it difficult for an agribusiness to use as a decision-making tool, let alone a smallholder farmer. The matrix would need to be refined in key ways to become a practical tool for different decision-makers.

- **For agribusinesses and investors:** a simplified matrix was developed to focus on the most important metrics through simplified questions, along with weighting, while also

creating space for more subjective scoring guided by input from technical experts and adapted to each context.

- **For smallholders:** the information in the matrix can be used to create a simple, user-friendly 'decision tree'. This is an area for future work, which could take the form of a mobile application guiding the farmer through a series of questions based on matrix data matrix. (E.g.: Where is your farm located? What base crop are you growing? What type of soil do you have? Do you have access to inputs?). The answers would generate rotation crop recommendations compatible with the base crop, available in Kenya and suited to each farmer's individual situation.

Findings

The draft matrix tool (Appendix 2) has been refined according to the considerations and challenges discussed in the previous section, and filled with data on the maize benchmark and each of the five test rotation crops.

The final tool establishes four levels of analysis in the following order:

1. **Compatibility** – the first questions determine whether a crop could be grown in rotation with a cereal base benchmark (maize), based on agronomic requirements and crop cycles, and at little additional cost to the farmer in terms of planting, weed and pest control, harvesting and storage.
2. **Rotation benefits** – for compatible crops, this series of questions determines the rotation crop's benefits on soil fertility, weed and pest control. This enables direct comparison of rotation options.
3. **Market potential** – if a crop is compatible and offers strong rotation benefits, what is its selling potential? This group of questions measures the market size, potential and path to market, locally and globally.
4. **Business case** – once a crop is determined to be compatible and beneficial and have strong market potential, this section can assess potential farm profit based on size, yield and crop prices.

The refined matrix retains only the most important variables, stripped down to a series of simple, clear questions. It is a high-level tool that can be used by agribusinesses and investors to score and compare various rotation crop options. The progressive levels of questions (compatibility, rotation benefits, market potential, business case) can also be used to develop a simpler questionnaire for farmers, to produce a list of rotation crop options and choose the best ones for individual farms. Applications and tool development will be discussed further in the recommendations section below. A more detailed review of the respective benefits of the five selected crops is listed in Annex 3.

Summary Findings: Testing the Matrix on Five Rotation Crop Options

	Soya	**Oats**	**Green Grams**	**Field Peas (*Pisum sativum*)**	**Quinoa**
Data availability	High	Medium	High	High	Low
Performance according to tool *-Total score (avg. out of 3)*	2.06	1.82	1.95	2.45	2.12
-Compatibility (avg. out of 3)	2.23	2.58	2.50	2.60	2.86
-Rotation Benefits (avg. out of 3)	3.00	2.33	1.40	2.80	1.67
-Market Potential (avg. out of 3)	2.00	2.36	1.89	2.40	1.94
-Business Case (1 = weak; 2 = moderate; 3 = strong)	1	N/A	2	2	2
Alignment with understanding of the crop outside the tool	Well aligned	Somewhat aligned	Well aligned	Well aligned	Somewhat unaligned; niche market.
Weighting	Business case may be especially important	More data needed to establish business case	Strong weighting on rotation benefits could change score significantly	Important for weighting on market potential and business case	Important for weighting on market potential and business case

Soya

Data availability

Good data are available from various sources; soya is well established globally, and in nearby countries such as Uganda and Zambia. Data are comparable across sources. However, soya is not well established in Kenya. TechnoServe and other stakeholders have recently produced useful research on the potential for soya market development there.

Performance according to tool

Soya presents 'medium-level' compatibility with maize. The crop has a number of specific diseases and pests, but it can be planted and harvested with similar machinery, and presents very strong rotation benefits. Availability of good quality soya seed is a major challenge for farmers in Kenya. This, along with a lack of local infrastructure for soya and strong competition from regional producers, could hinder expansion in Kenya despite high local and global demand. The importance of these factors should be explored further, through weighting of the matrix scores.

Alignment on understanding of the crop outside the tool

Soya scores reflect our understanding of the crop as having strong rotation benefits and global market potential, alongside a weak business case for farmers locally.

Weighting

For soya, the weak business case for farmers and lack of local market access and processing infrastructure could outweigh the rotation benefit potential. This would need to be considered in the context of farmer goals and financial positions. Would it make long-term economic sense for farmers to grow soya for rotation benefits without the promise of market access or financial benefit? What would the related financial benefits be to farmers of improved soil fertility and maize yield? How strong is the case for potential yield increases? These variables could also change significantly with increased market development support from industry stakeholders and the government.

Business case (market potential)

Currently challenging for farmers in Kenya, but could change significantly through industry development support. Access to reliable sources of quality seed is expected to increase the crop's average yield for Kenya from < 1 t/ha to up to 2 t/ha.

Oats

Data availability

Medium – there are strong agronomic data available for oats but poor market data for Kenya. Further research is required for value-added oat products such as porridge, domestic animal feed and cosmetics.

Performance according to tool

Oats are highly compatible with maize. Both crops require similar climatic, agronomic and topographic conditions. Oats have a high tolerance to diseases and pests, and require minimum inputs. Rotational benefits include disease, pest and weed control, but oats remove nitrogen and phosphorus from the soil. While seed remains available throughout Kenya, there is concern about the appropriate milling varietals.

Local oats demand remains unmet, both as a commodity and value-added product(s). Global demand is high, but Kenya lacks processing infrastructure and facilities. Building a coherent oats business case for Kenyan smallholders is difficult, as they tend to offer a limited yield potential. However, farmers may be growing oats for non-monetary benefits, such as breaking disease cycles and reducing the need for chemical crop protection. The importance of these factors should be explored more through weighting of the matrix scores.

Alignment with understanding of the crop outside the tool

Oats scores are somewhat aligned with what is understood outside of this tool. Oats score high on compatibility, rotation benefits and market potential, but there remains a large context and data gap on the business case for oats grown by smallholder farmers in Kenya.

Weighting

Starting with data collection and investigation, greater emphasis, should be put on upper yield limits, as well as on minimum operation size/acreage for smallholder profitability in Kenya. This should be followed by a stronger weighting of the business case.

Business case (market potential)

Currently very weak due to lack of data. There is a need for more data on upper limit elements for oat growers in Kenya.

Green Grams

Data availability

Good – green grams are a well-established food staple commodity with high production and strong demand globally. Data on growth and sales in Kenya are also available.

Performance according to tool

Green grams require some special machinery to harvest and store, which could be costly for small-scale farmers, although the crop does not require high input costs. Growing conditions for maize and green grams are highly compatible, and the crops offer similar features such as water requirements. The crop does not offer strong rotation benefits for soil health or weed control, but does have some pest control benefits. Green grams fix nitrogen, but their rotation benefits for maize yields may be limited (see Green Grams matrix). Market potential is also mixed, with strong demand from India, but regulatory uncertainty linked to Indian quotas and limited market access. However, the Kenyan government alongside donors and other stakeholders are strongly in support of developing the market for green grams locally.

Alignment with understanding of the crop outside the tool

Green grams' score reflects strong compatibility for maize farmers in Kenya and current growth of the industry, but relatively weak soil fertility benefits and an embattled export market.

Weighting

The importance of rotation benefits and soil fertility could be a large question for farmers interested in growing green grams with a cereal base crop. Many Kenyan farmers already grow green grams as a core crop because of its hardiness (especially drought tolerance) and strong consumer demand. This may present a separate market from the focus of this study and tool, which is on rotation benefits for cereal base crops.

Business case (market potential)

Currently challenging, because of a glut in local production and restricted access to the Indian market. But potentially strong with regulation of production and development of local demand with strong government support.

Field Peas (*Pisum sativum**)

Data availability

High – there is a considerable breadth and depth of information on agronomy, production, rotation benefits and market potential for field peas at a global level. Data are available on the same segments in Kenya, but not to the same degree. There remains a particular gap in data required for a clear path to the international market for Kenyan farmers.

Performance according to tool

Field peas had the highest overall average score, standing out on rotational benefits and market potential. Field peas are highly compatible with maize, as they require similar inputs, grow at similar soil pH, and both need to be dried after harvest. Smallholders use similar non-mechanized planting techniques for both crops, and often inter-plant them.

Field peas are a good source of plant-based protein, and global demand is high (notably in India and China). In Kenya, there is demand for field peas as food and animal feed, but regular competition from Uganda and Rwanda. Field peas are available across Kenya, but the off-taker market remains opaque. Further analysis should illuminate the peas' route from farms to domestic and international markets. Greater investment in processing and value addition infrastructure should be considered, in order to remain competitive.

Alignment with understanding of the crop outside the tool

There is strong alignment between tool results and what is understood outside.

Weighting

A solid business case requires deeper understanding of industry development both nationally and regionally. A technical expert should provide guidance on market potential weighting, with a specific focus on demand / price stability or elasticity and on strength of competition.

Business case (market potential)

Areas for further exploration should include a profitability analysis of production beyond 2.47 acres/1 hectare per farm, and market creation opportunities for Kenyan field peas, including supplementary feeding programs/food rations during drought or famine.

***** Many different varieties are called "field peas"; this study refers specifically to *Pisum sativum*.

Quinoa

Data availability

Low – it is a challenge to find data for quinoa in Africa. There is a good breadth and depth of market and agronomy information for quinoa grown in South America. Some agronomic data are available for seed varietals and climatic conditions in South Africa, but there are few or no data on market opportunities for quinoa as a commodity in East Africa. Global potential remains large. Quinoa displays significant genetic variability, with varietals adapted to grow from sea level to 4000 meters, in both cold and subtropical climates. In Africa and Asia there is great potential for increasing production to meet local (future) and international (current) demand. Quinoa may be a good crop to provide highly nutritious food under dry conditions across both continents. In cooking and baking, it has the dietary advantage of being gluten-free. The crop is also used as animal feed, green fodder, pellets and modified food products.

Performance according to tool

Smallholders use traditional planting, harvest and storage techniques, including soaking quinoa in water between harvest and storage. Quinoa is a highly compatible rotational crop with maize and oats. However, it extracts nitrogen from the soil, so inputs are required. Quinoa is not a staple crop for Kenyans; it represents a niche market for health-conscious consumers. Overall demand is low, but there is so far also little competition. Quinoa commands a higher kilo price than field peas, green grams, oats and soya.

Alignment with understanding of the crop outside the tool

Quinoa scores well as a rotation crop for maize. In Kenya, however, sales are low compared to Germany and the USA, the leading importers. The high retail price in Kenya helps limit sales to a niche market. A major education drive would be required to increase demand.

Weighting

Overall, quinoa scores quite high. However, the low competition and demand relative to Kenyan staples would be clearer with more balanced weighting of quinoa's market potential (low) and business case (medium/weak) in East Africa. Business case (market potential) Strong for farmers/agribusiness already serving niche Kenyan food markets. Low/poor for (most) farmers in Kenya growing who grow staple commodities.

Recommendations

The matrix tool presented here is the result of iteration and testing across the initial five rotation crops. The goal is to develop a decision-making tool, or set of tools, for practical use by agribusinesses and farmers. To establish a final set of tools, further refinement and research are needed. Recommendations for this work are presented here.

Conduct a Technical Review of the Matrix Tool

Expert agronomists should conduct a technical review of the agronomic compatibility and rotation benefits sections. They should give special attention to the content, wording and flow of matrix questions and guidance notes for answering those questions. Local market experts can review the market potential and business case sections.

Technical experts should also establish the weighting system. This system should identify the relative importance of different questions in the matrix and weight them to ensure that scoring reflects farmer and agribusiness priorities and requirements when selecting rotation crops. The weighting system must be flexible and easy to tailor to reflect changing priorities depending on the user, region, and base crop context.

Develop Additional Cereal Baselines

The current matrix was developed with maize as a cereal base benchmark. This included research on husbandry and the various agronomic and geographic conditions required to grow maize in Kenya. This research did not consider in depth how these requirements may vary between varieties or growing regions. The baseline could be developed further to address specific cases, such as maize farming in a particular region. It can also be developed for other common cereal base crops grown in Kenya and other countries, such as wheat and barley. Priority could go to crops grown by large numbers of farmers. The development would require further research and consultation with agronomy and market experts.

Create Tools for Smallholder Farmers

In its current format, the matrix tool compiles a comprehensive list of considerations for rating rotation crop options and market potential. This format will be useful for agribusinesses and investors weighing investment decisions, who will need to consider many variables and compare various options.

This format is too complex to serve as a decision-making tool for smallholders. However, the information for cereals and rotation crops can also be used to populate simpler tools:

Questionnaire Tool

A series of questions can be developed to help farmers identify optimal rotation crop options. These questions would begin by establishing a unique baseline defined by the individual farmer: e.g. farm size and location, soil type, cereal and other crop varieties currently grown, access to equipment and inputs, etc. Additional questions would determine the farmer's priorities in selecting a rotation crop (e.g. improved soil fertility vs. additional income), and the farmer's financial position.

His or her answers would lead to an individualized list of recommended compatible rotation crops. The list could present each crop's rotation benefits and market potential.

Decision Tree

The questionnaire tool defined above could also be adapted into a decision tree structure with a series of “if, then” questions. These questions would move in order from the most important considerations (questions with the highest weighting in the matrix tool) down to less important. For example, the tree might begin by asking questions about the farm location and cereal base crops under cultivation. If a farmer answers “maize, Western Kenya”, the following questions would relate specifically to that crop and region, narrowing down rotation crop options along the way.

Adjust the Tools for Other Countries and Contexts

The matrix is designed to be a flexible ‘skeleton’ tool that further research can adapt to different countries and contexts. This could include adapting a maize cereal baseline to other East African countries. Rotation crop potential will also vary significantly by country, in terms of agronomy, market establishment, demand and production trends. Furthermore, the rotation crop performance will need to be updated over time to reflect political, regulatory and economic changes in each country.