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Maximizing Production and Minimizing Risk. Soy Production and Agricultural Systems for Small Producers in the Province of Huambo and Bie, Angola.

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INTRODUCTION

The soybean has a set of features that allow it to be highly valued in terms of nutrition and agricultural development. Agriculturally, soy beans have the ability to fix atmospheric nitrogen for use by the growing plant and crops to be grown after the soybean rotation (Chianu, et al, 2009; Misiko, et al, 2008). Moreover, soybeans are relatively easy to grow and have a low incidence of pests and diseases.

Nutritionally, soy is the only plant source of "complete" protein based which means that it provides sufficient amounts of all eight amino acids that the body cannot make on its own. Soy protein quality also outranks all other protein sources, except egg whites. Soybeans also provide a number of additional vitamins and minerals and are a source of Omega 3 and fatty Omega acids, all of which combine so that it can be regarded as a highly nutritious food (American Soybean Association, 2004).

This combination of agronomic and nutritional properties of soybean make it key in systems for improved soil fertility for agricultural development, while the affordability and nutritional value of soybeans make it popular for food aid.

Angola has good potential for agricultural production, given the amount of land available (58 million hectares), its suitability for agriculture production (for instance, more than 90% of the country is suitable for soybean production in terms of fertility and clime), and its fertility (some areas can achieve 2 seasons of soybeans without irrigation) (TechnoServe, 2011).

In Angola the cost of producing soybeans for small producers varies between \$300 and \$600 per ton (National Agricultural Marketing Council, 2011)**1**. The main problems are low yields (which vary from 150 to 250 kg per Ha.) and a lack of access to markets, lack of knowledge on production, and lack of cohesive industry bodies (TechnoServe, 2011).
Often farmers use local seeds that come from previously harvested seeds. And while seed traders sell enhanced, imported seeds, they sell them at a rate that makes it impossible for small farmers to purchase them without subsidies. Therefore local farmers are left without alternative seed options and are essentially forced to use local varieties that are poorly selected and of low quality.

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1. This data is from the **National Agricultural Marketing Council**, 2011. The cost of production varies according to the system and is dependent on the inputs, type of soil preparation, etc.

On the other hand, imported seeds are not adapted to the local conditions as they demand for higher rates of fertilization application and intense labor. As a result, post-harvest losses are very high, ranging between 30% and 40%. These losses are due to lack of pre-storage and selection, in addition to poor drying practices. The technical assistance to small producers is at the heart of harmful traditional agricultural practices.

Recently the demand for soybean production has escalated in the province of Huambo and Bie. According to Aecom international development "Angola is the only other significant importer of soybean oil from outside the region (~95k MT)**2** while the demand will increase by 7% (AECOM, 2011). In Angola 70% of the production is dominated by commercial producers while only 30% of the production comes from small producers (AECOM, 2011). Paradoxically, the annual production of soybeans in Angola is low, despite a high demand within the food processing industry and animal feed (National Agricultural Marketing Council, 2011). Field research data asserts that the region can obtain yields ranging from 1.2 to 2.5 tons/hectare when using improved germplasm. Soy is an important crop with clear properties that can positively contribute to soil health, nutrition and human health, nutrition of livestock, family income, poverty reduction and overall improvement of livelihoods and ecosystem service.

The majority of the challenges are for small producers that face obstacles including access to inputs, improved seed, agronomical assistance, as well as organizational challenges. Therefore, the local cooperatives need assistance identifying varieties that can be adapted to the local conditions, multiplying these varieties at a cooperative level as well as, selecting the fields and storage using the prototype stores and distribution to their members.

The CODESPA Foundation has been working in Angola since 2010 on a rural development four-year program, with a focus on value chains. CODESPA in coordination with UNDP and the Spanish Cooperation Agency (AECID) is strengthening small farmers associations and cooperatives through the promotion of soy production and commercialization, in the provinces of Huambo and Bie.

The goals of this project are: (1) Improve the seeds multiplication system in the cooperatives. (2) Improve the production and productivity of the soybean plantations in Huambo and Bié. (3) Improve the storage capacity of the small farmers. (4) Improved the sales ability of the cooperatives. (5) Strengthen the management ability in five cooperatives.

This report focuses on goal number two by looking at how to improve the production system of soy, after its first planting season, by analyzing the producers and factors that impacted their production. To date the project has selected five cooperatives in Huambo and Bié and conducted an agricultural diagnosis with them. The Agronomical Research Institute of Angola (IIA) and CODESPA started up five farmer field schools **3** to train the members in best practices of the soybean crop. In this process monitored the farm of approximately 60 ha of soybean in the cooperatives. During the course of the project has been done training courses in the different phases of the crop production (seed selection, farm, weed, harvesting and storage) in all communities.

GOALS

1. To determine if the average yield had increased by using the new seed varieties and technology package.

2. Determine the factors that explain the variation in the productivity (Kg/Ha).

2. 'Soybean equivalent' refers to the amount of raw soybean required to produce 1 MT of cake and 1 MT of oil respectively; this is based on the assumption that processing 1MT of raw soybean produces 80% cake and 18% oil. In other words, 1 MT of meal requires input of 1.25 MTs of soybean, and1 MT of oil requires input of 5.56 MTs of soybean.

3. Farmer field schools are traditionally an adult education approach -a method to assist farmers to learn in an informal setting within their own environment. FFSs are - schools without walls, where groups of farmers meet weekly with facilitators. They are a participatory method of learning, technology development, and dissemination (FAO, 2001) based on adult learning principles such as experiential learning (Davis and Place 2003).

3. Establish recommendations that may increase the production in the next cropping cycle.

PROJECT SITE

The project is set in the Provinces of Huambo and Bie in Angola. The province of Huambo is located in the central highlands of Angola, characterized by a mild tropical climate, with altitudes between 1,000 and 2,500 m. This plateau recorded rainfall between 1,250 and 1,500 mm/year and an average temperature between 18 -ʃ20ʃ. Soil preparation for maize begins in September with the first rains. With an area of 34,270 km^2 it is one of the geographically smaller provinces, situated in the Central Region approximately 450 km south east of the capital, Luanda.

Huambo is one of the richest agricultural provinces in Angola. In 2011-2012 the province produced 22.3% of total national cereal production: 106,000 tons out of a total of 554,343 tons (Relatório da campanha agrícola. IDA. 2012-2013). As a result of improved security, areas used for cultivation in the Province have increased during the past years to about 500 km². This represents the largest increase in the country since the end of the war.

The principal crop is maize with almost 423.022 ha under cultivation (Ministério de Agricultura de Angola, 2013). Yields are low, an average of 723 kg per hectare. The second crop is bean with 127.712 ha under cultivation and an average yield of 357 kg per hectare. Soybean has been cultivated historically in Huambo, having a peak of cultivated area in 2012 of 23.788 ha (Relatório da campanha agrícola. IDA. 2012-2013). Bié is a province of Angola located on Bié Plateau in central part of the country. Its capital is Kuito and it has an area of 70,314 km².

The climate of Bié is tropical with relatively small temperature variations during the year (average 20 ° C) and annual rainfall between 1,200-1,400 mm. The dry season begins in early May and ends in early August and at that time there is almost no precipitation until September. There is very little agriculture during the dry season, unless there is access to irrigation during this time period.

FARMING SYSTEM AND SOIL

This study is using a farming systems research and extension approach. Farming systems research is an approach for generating appropriate technologies for studying existing farming systems and involving the technology users - usually the small farmers in the planning and evaluation process. The approach is justified on the basis of three vital considerations. Firstly, the farmer and his family are rational in their decision-making. Secondly, the production systems of small farmers embody an integrated set of husbandry practices that have developed over centuries so that these systems are stable, complex and very sensitive to the ecological, biological and socio-economic environment. Thirdly, a farming system belongs to the goal-setting and purposeful category of systems and its direction is determined by the farmer and his family.

The decision to introduce changes or adopt any innovation depends entirely on how the household assesses the relative advantages and disadvantages in terms of its own perceptions and priorities. Because of these considerations, FSR is an interdisciplinary, integrative, problem-oriented and farmer-centered approach.

Farming systems research deals with fitting technological innovations within the traditional system. The analysis has to be conducted in a series of progressive steps, summarized as follows:

1. The ecological and physical environment. Soil capabilities, rainfall patterns, temperature levels and their relationships are the basic determinants of technological design;

2. The socio-economic environment. Technologies are determined and do affect social customs, religious beliefs and values, age and sex occupational roles, forms of social or communal organizations, credit policies, input markets, product markets and as a very important factor: history, understood as the evolution of the farming system, etc.

3. The family goals and objectives. The introduction of a particular technology may interfere with other goals and objectives;

4. The sub-systems. Conflicts may be intensified or reduced with respect to the management of other sub-systems;

5. The farm resources. New technologies directly affect the use or replacement of locally existing resources, tools or techniques. They may be too difficult or complicated for the farmer to manage.

One of the key concepts examined in this paper is risk. Risk is defined as the product of hazard and vulnerability. In other words, it relates to the probability of a damaging event, such as drought, and the foreseeable consequences of such an event. The risk of war and the resulting food insecurity are difficult to predict and this paper will not consider them further. In terms of agriculture, the most common risk is drought. On a global scale, this risk is much greater than that of cyclones, floods and storms. However, on a regional rather than global scale, there are areas where the risk of flooding exceeds that of drought.

Drought represents one of the most important natural triggers for malnutrition and famine.

Farmers manage this risk by:

- Diversifying enterprises, particularly with livestock.
- Being flexible in crop area and crop type.
- Adjusting inputs in response to season.

Risk was an important element in the examination in this paper. We specifically examine risk in the production of the crop production and create recommendations that will minimize it.

In this case the goal is to examine how "improved soy bean production" may be related to current farming systems in Huambo and Bie. Furthermore Farming Systems Research and Extension has developed a protocol by which current On-farm research may be examined.

The majority of soils in Huambo and Bie are Ferralitic. They are generally very desaturated, acidic, (frequent pH of 5 - 4), deficient in P and N. and poor in bases. They seem on the whole very permeable, except where they have been compacted (tracks, cattle trails, paths to dwellings) or pounded by rain. They retain little water (1 mm of available water per centimeter of soil) or nutrients (1 to 5 meq/100 g of fine soil), so that it is important to maintain an adequate level of organic matter.

Farming Systems in Huambo

This study looks at both the ecological aspects of farming systems as well as a typology of the different producers. Abdelli and Jouen(2013) conducted an agricultural diagnostic in the Provinces of Huambo and Bie which included transects of production and soil. The transect from Assango in Huambo shows at the upper levels there is no agricultural production (see Figure 1). At the lower two levels there is maize and cassava, goats, horticultural products, fallow, maize, beans, houses, bananas, pigs, goats, and, chickens.

The different systems are essentially associated with access to water as being the great divider.

The second figure shows a transect in Cossito that is somewhat different with a higher altitude. There is no production in the highest area, at 1,880 m there is horticultural produce and maize, and at 1,834 and 1,763 m there is horticultural produce, potato, and beans. In the same altitude there is another system close to the water with beans/ maize, horticultural produce, potato, sweet potato, sugar cane, bananas, and small animals. These transects are important as they show the manner in which soils and altitude impact the different cropping systems. Soils often determine the amount of time these systems may actually be farmed as may be seen in the systems adopted by farmers.**4**

Besides the diversity in the farming systems in terms of soil and access to water, Beade and N'Tab (2013) created a typology of five different agricultural systems available to "small subsistence farmers," "farmers slightly diversified," and "small producers that hire outside labor."

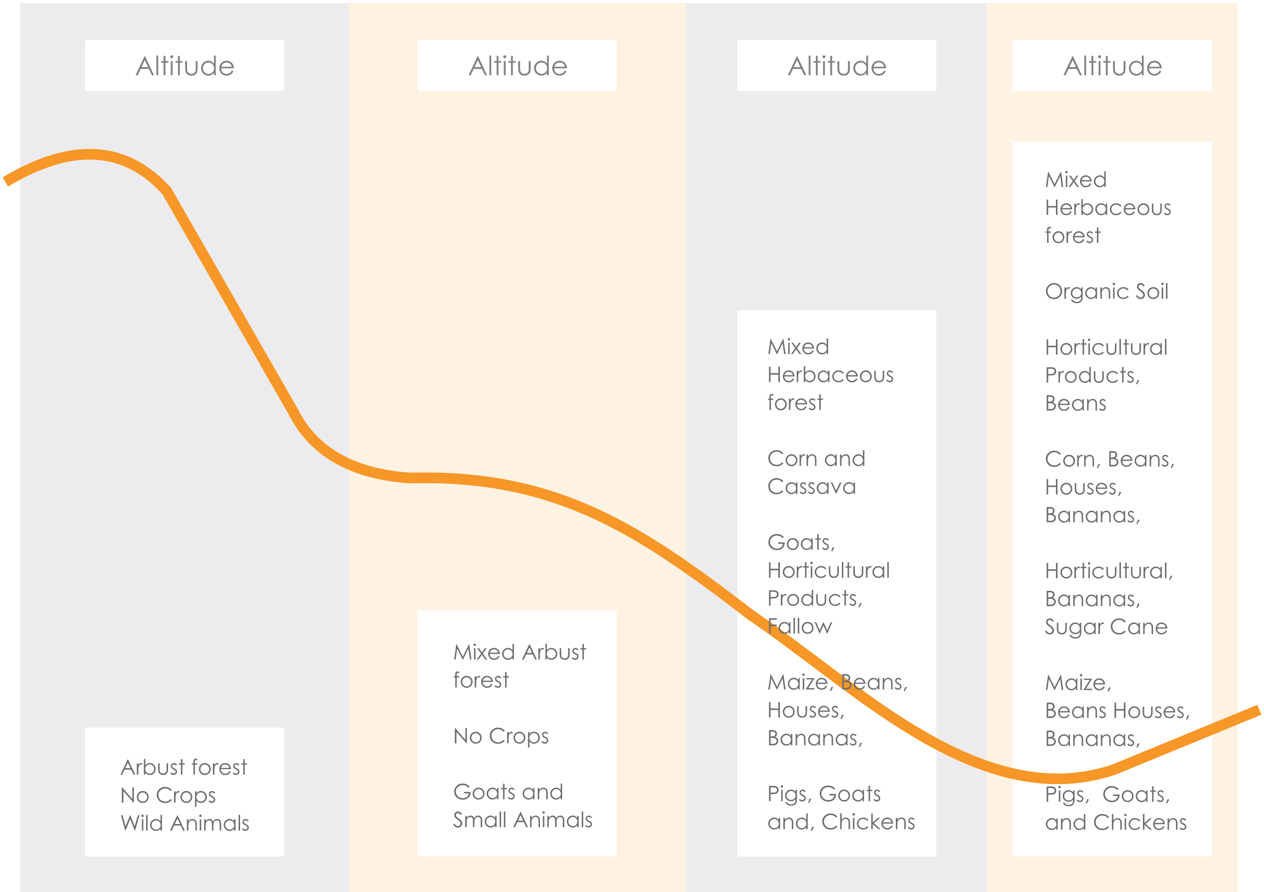

Figure 1. Assongo (Adapted from Beade and N'Tab, 2013.

The first agricultural system is only maize. It is perhaps the single most important determinant of welfare in the central regions of the country where it is the staple grain. Maize is a family crop and is cultivated on the largest area in all zones. It is the first crop to be sown after the rain starts. Soil preparation for maize begins in September.

It is normally planted on virgin land which includes slash and burn of the area. It is also the first to be weeded and the first to be harvested. Thus the main concern of every cultivator is to fill up the granary bin with enough of the whitish maize to feed his family until the next harvest. The surplus is sold in the market.

4. In personal contact with Fransisco Carranza (2013) of FAO. He points out that higher altitude soils are farmable, the farmers simply do not need to go up there to slash and burn for more arable land (not yet at least).

The second system is maize, as shown above, rotated with beans. In the second year beans are planted October and harvested in January and February. In some cases the two are intercropped in the first year (Beade and N'Tab, 2013). Common beans andmaize are important crops for smallholder farmers in Angola, with approximately 36% of households in a recent survey indicating that common beans were the most important source of cash income from crops. About two thirds of household production was sold, for those households growing beans (MSU, 2012).

The third system is composed of maize, beans, and tubers. The system is composed of maize in the first year, maize and beans in the second, and either sweet potatoes or cassava in the third. All of the planting is done with the rain and then the land is to be put into fallow for two years (Beade and N'Tab, 2013).

The fourth system is a combination of tomatoes, onions, and cabbage. In this case these are for those that have additional land with access to irrigation and/or access to onakas (in the lower lands) that keep the soils moist and are farmable all-year round (Carranza, 2013). The tomatoes, onions, and cabbage are planted in February, transplanted in March, and harvested in July.

The fifth system is potatoes, lettuce, and onions. The onions are the first to be planted in February and this is followed by other horticulture products in March. These are the weeded, watered, and harvested in July (Beade and N'Tab, 2013).

The "small subsistence farmers" conducted maize, maize/ beans, and the maize/ beans/ tubers systems on less than two hectares. These farmers depend on family labor and use all manual labor except for children in the soil preparation and many in the processing of maize. If they have any animals at all it would be chickens (Beade and N'Tab, 2013).

The "farmers that are slightly diversified" will use maize, maize/ beans, maize/ beans/ tubers and potatoes/ lettuce/ onions systems. They have access to animal traction and cultivate between two and five hectares. They also have approximately a half hectare under irrigation. These producers also have pigs as well as chickens (Beade and N'Tab, 2013).

The "small producers that hire outside labor" produce maize/ beans, maize/ beans/ tubers, tomatoes/onions/cabbage, and potatoes/ lettuce/onions systems. These producers have capital increased access to animal traction and outside labor. Furthermore many will have access to more than five laborers acres and much of their production will be geared to external markets (Beade and N'Tab, 2013).

The typology shows some important trends in terms of the potential of soy in Huambo. First the typology shows the importance of cost, access to seeds, and other constraints such as lack of irrigation systems, low fertility land, etc., for the subsistence farmers (Carranza, 2013). Soybean may be grown on large-scale high-input farms as a monocrop or by small-scale farmers either as a sole crop or mixed with sorghum, maize, or cassava. Very little or no inputs (fertilizer or pesticides) are used, and field operations such as planting, weeding, and harvesting are usually done manually. Soy can easily fit into a similar position as the beans and can potentially benefit all targeted producers. The subsistence producers, however, may lack capital and would need seeds to get started.

Another advantage of soybean is that it improves soil fertility by adding nitrogen from the atmosphere. This is a major benefit in African farming systems, where soils have become exhausted by the need to produce more food for increasing populations, and where fertilizers are not available or are too expensive for farmers to buy.

Figure 2. Cossito (Adapted from Beade and N'Tab, 2013)

Farming Systems of Bie

Once again the soils in Bie span between sandy to ferralitic. Figure three shows a very similar situation to that showed in Huambo. In the low areas where there is water, there are horticultural crops, sugar cane, maize, and bananas. In the higher rain fed areas there are potatoes, maize, beans and cassava (Abdelli and Jouen, 2013).

Abdelli and Jouen (2013; see Table 1) laid out the different cropping systems used in Bie. These systems vary according to the area in which they are carried out, as well as the physical and economic resources of the farmer. The first cropping system (CR1) is simply a maize system in an upland rain fed area with no rotation or fallow. The second system is upland rain fed with maize and cassava with maybe some beans and sweet potato mixed in. There is also no fallow in this system unless it fails to produce.

The third cropping system is a hillside maize and bean system with intercropped with cassava and sweet potatoes. This is followed by a period of rotation with maize and beans for two years. Cassava is then planted for two years and then the land is left in fallow for three years (Abdelli and Jouen, 2013).

Maize, beans, and cassava make up the principle crops of system number four. This is intercropped with sweet potato, inhame, and squash on a hillside system. These primary crops are planted for three years followed by cassava for another two. After this the land is left in fallow for five years (Abdelli and Jouen, 2013).

Cropping system five is primarily a maize and bean system mixed with sweet potato, yam, and squash. These crops are then replanted and then the hillside is left in fallow for one year. Pineapple and maize are repeated for three years in cropping system number six and then left in fallow for two years (Abdelli and Jouen, 2013).

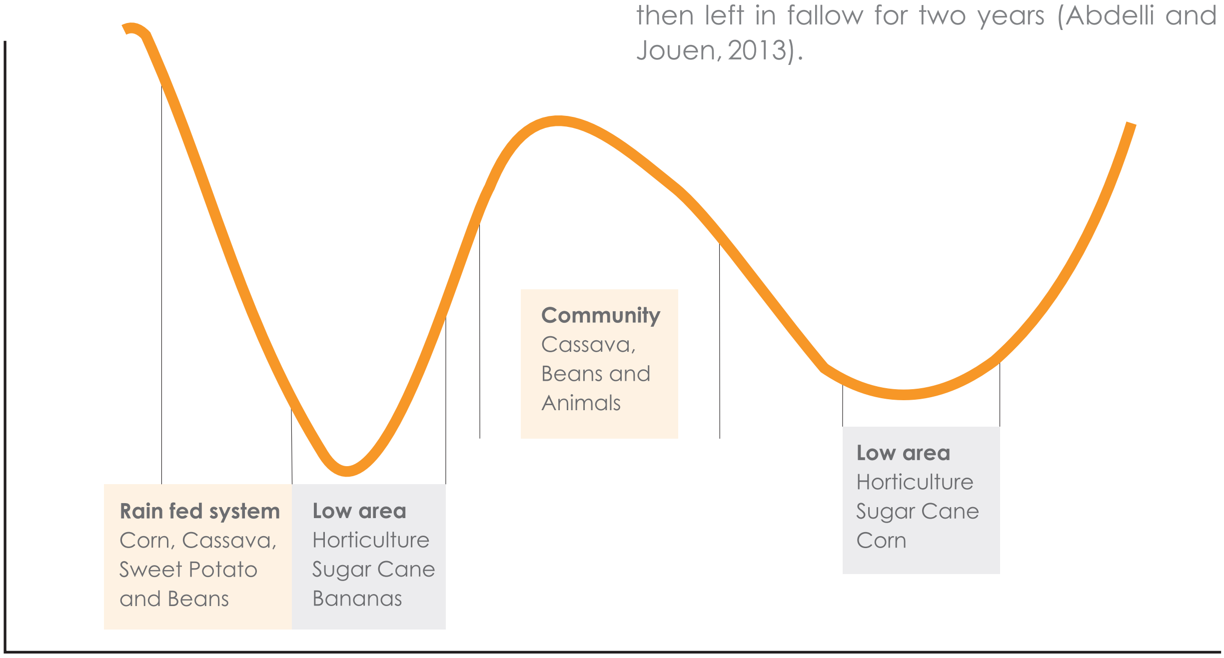

Figure 3. Kalucinga (Adapted from Abdelli and Jouen, 2013)

CROPPING SYSTEMS IN BIE

Cropping System	Time	Principal Crops	Secundary Crops	Distribution and Qualities of the Soil	Rotation and Fallow
CS1	Rain	Maize	Cassava	Sandy Soil Above	No Fallow
CS2	Rain	Maize+Cassava	Beans and Sweet Potato	Sandy Above	None - No fallow unless the land does not produce
CS3	Rain	Maize+Beans	Cassava and Sweet Potato	Land on the Hill	(C, B, Cas) x2 (Cas) x2 left in fallow x 3
CS4	Rain	Maize+Beans+ Cassava	Sweet Potato + Yam + Alfalfa	Land on the Hill	(C, B, Pot, I, A) x 3 (Cas) x 2 left in fallow x 5
CS5	Rain	Maize+Beans	Sweet Potato + Yam + Alfalfa	Land on the Hill	(C, B)-(C, Pot)-(I, Cas)-(B,Cas) left in fallow x 1
CS6	Rain	Pineapple	Maize	Land on the Hill	(Pine, maize) x3 -left in fallow x 2
CS7	Dry	Maize	Cabbage+ Sugar Cane	Lowland	No fallow= everything is mixed
CS8	Dry	Maize+Beans	Tomato+Cabbage	Lowland	(C, B) (T,C) No fallow
CS9	Dry	Tomato+Cabbage	Onions+ Sugar Cane	Lowland	T-C - Onions - No fallow
CS10	Dry	Tomato+Cabbage	Onions+Alho+ Carrots+Sugar Cane	Lowland	T-O - Carrots - No fallow

Table 1. Cropping Systems in Bie. Abdelli and Jouen (2013).

The dry lowlands include maize, cabbage, and, sugarcane (CS7) which has no fallow. Cropping system eight is maize and beans intercropped with tomato and cabbage. Tomato and cabbage are combined with onions and sugar cane in cropping system nine. The final dry lowland system (CS 10) is tomato, cabbage, onions, garlic, carrots, and sugarcane. In systems eight, nine, and ten the crops are repeated with no fallow (Abdelli and Jouen, 2013).

Abdelli and Jouen (2013) also created a typology for the different producers (see Table 2). The first are small family farmers with limited labor because they are a young family or maybe a widowed female headed household. They normally have access to sandy hilltop soils with 0.45 ha or less located up to (8-12 km) away from their villages. They have no capital for investment or for contracting outside labor. They will normally crop CS1, CS2, CS3, and CS7 as seen in Table 1.

The second group is very similar to the first group but with children that can help and slightly more capital which may be invested in agricultural activities. They have access to some more land (0.8 ha) located between 4 8 km away. These producers are involved in cropping systems two, three, four, seven, and eight (Abdelli and Jouen, 2013).

The final categories of producers shown by Abdelli and Jouen (2013) that will be used in this study are intermediate sized. These farmers have larger families and are strong kinship networks. In the absence of 'formal' financial markets and insurance opportunities, many people in developing countries depend on informal community structures to provide social security and reduce their exposure to risk (e.g., Rosenzweig, 1988; Fafchamps, 1991; Townsend, 1994; Udry, 1994; Fafchamps and Lund, 2003). A key role in this respect is played by the extended family (kinship), where membership of a kinship network is acquired by bloodlines, marriage, or adoption. Kinship is a collective institution, and represents a primary principle of social organization in sub-Saharan Africa, governing social relationships and marital customs, and regulating access to resources and services.

These farmers have access to over 0.8 ha of all types of land including lowland for horticultural production. They also have access to animal traction and have capital for investment and outside labor. The cropping systems utilized are CS4, CS5, CS8, and CS9.

TYPOLOGY OF THE DIFFERENT PRODUCERS IN BIE

System of the Production	Characteristics of the Community and its Population	Utilisation of Natural Resources	Economic capital and External Labor	Cultivation System
SP1. Small family that is highly.	Young, Married, Widowed, Disabled from the war, Agriculturally employed.	Family operated with ≤ 0,45 Ha. Sandy soils on top sometimes sloped, These are frequently far away (8-12km) and access to lowland is limited.	Very Limited. Does not allow for any investment in agricultural activity.	**CS1** **CS2** **CS3** **+** **(Cs7)**
SP2. Small family subsistence a Little diversified and somewhat stable.	Families with children that help.	Family ≤ 0,8 Ha Sandy soils on top sometimes sloped, frequently far 4 8km, Access to lowland is limited	Very Limited. Only can invest in agricultural activities. Use some external labor.	**CS2** **CS3** **CS4** **+** **CS7** **Cs8**
SP3. Intermediate sized and stable sometimes diversified and specialized.	Large families recognized by the community.	Family>0.8 Ha All types of land.	Limited but stable. Allows investment and external labor when necessary.	**CS4** **CS5** **+** **CS8** **Cs9**

Table 2. Tipology of the different Producers in Bie. Abdelli and Jouen (2013).

In this case the work done by Beade and N'Tab (2013) and Abdelli and Jouen (2013) serve as a point of departure. In both cases, Huambo and Bie, the project looks at the introduction of soy into the farming system and considers the viability in terms of production for small family subsistence farmers. This means that the technology must be balanced in terms of increasing costs found in the current system including fertilizer, labor, seed, and fungicides.

The project has, however, started with farmers that would be in the third category (in both communal land and individuals, but with the same configuration and characteristics). For the seeds multiplication program 15 farmers were selected, three per cooperative, satisfying the following criteria:

1. Producers that belong to the cooperatives involved in the project, which are known to be honest and are appreciated by the community.
2. Producers that have a minimum area of 0.5ha for soya production.
3. Producers with good quality plant development.
4. Producers with technical knowledge of soya cropping.
5. Producers who do not depend on the soya cropping for family consumption.
6. Producers with diversified sources of income.
7. Producers with an investment capacity between 250 and 300 USD.

As it may be seen, the project started working with producers with some income that could be invested, instead of working directly with subsistence farmers. This decision was made in order to not directly harm the farmers or to their families in case of crop failures. In this regard is very important to understand the relationships between the categories established by Abdelli, H and D. Jouen (2013) in which the third category employs the first one as labor force. This means that the best way to transmit know-how to the subsistence farmers, minimizing the risks of crop failures, is to work with the ones found in the third category, and even more if we take into account that the technology package use by both categories is quite similar and the transmission of improvements can be adapted by the poorest.

On the other hand, the idea of the project is to create a product (the improved crop technology) that will be usable by all farmers. Simplifying what the project looks for is improving the production while trying to minimize costs. The overall strategies include using practices that (a) grow healthy plants with good defense capabilities, (b) stressing pests, and (c) enhancing populations of beneficial organisms. These are accomplished by enhanced habitat management both above ground and in the soil. Many of the practices that contribute to the overall strategies are well knownsuch as intensive use of cover crops or reduced tillage. The trials were conducted and analyzed.

METHODS

FSRE (Farming Systems Research and Extension) is a process of identifying, fitting and screening technological innovations (components, inputs and/or management practices) into the traditional system, which should solve the farmers' problems. Design objectives pertain to particular levels of desired performance, income generation or welfare, defined in conjunction with farmers.

In this case the research focused on the production per hectare of Soy. The project is essentially evaluating the production of the soy while taking into account the other factors such as economic, ecological, and social factors.

It is a fact that the cultivation of soybeans in combination with other crops is one of the most profitable ways through which farmers can maintain soil fertility. Consequently, biological nitrogen fixation to soybean crops with a dual purpose (grain and biomass) is a great opportunity to reduce the cost of the acquisition of mineral fertilizers by farmers with limited resources, which often cannot afford to purchase them. Soy improves soil fertility by adding 44 to 103 kg of nitrogen from the atmosphere (Sanginga et al., 2003) and reducing the need for simultaneous crop fertilizer / post.

In order to pursue productivity improvements in the selected 15 farms, within the five cooperatives, conducted trials by means of the "Farmer Field School" methodology. This methodology aims to guarantee the dissemination and replication of best agricultural practices among the cooperatives in the intervention areas.

Objective number one was to determine if the average yield had increased by using the new varieties and technology package. The production data from these trials was weighed and calculated. The mean average was calculated and compared to previous reported yields taken from the preliminary agricultural analysis. (See Annex 1).

Objective number two was to determine the factors that explain the variation in the production (Kg/Ha). The analysis of the crop production focuses primarily on the ecological and cultural aspects of the soy production from 15 community managed farms in Huambo and Bie. In terms of the ecological variables the two main components have focused on both soils and rain. There is no quantitative variable in terms of soil fertility or amount of rain. There was, however, lots of qualitative including cropping history, soil type, organic material, the distribution of the rain, etc. This information was used to qualitative scale from 1-10 with one being the lowest and ten being the highest for both soils and rainfall. All of the team members had to evaluate the criteria and scores in order to validate the rating.

Other management and planting information was also taken into consideration when looking at the difference of the production including planting distance, kg per hectare of seeds used, date of planting (important for rainfall), number of weedings, and incidence of diseases or pests.

Paired T-tests were used to compare the soil and the rain to the yield results. Paired tests are superior to tests for independent groups and provide more information than independent group tests because there can be substantial variation in the environment for replications, all of which are on different farms.

Adaptability (formerly called modified stability) analysis was used to assess the production of the soy. It is a technique that has been developed to compare the performances of cultivars across different environments. The technique involves regressing or drawing the yield of each variety at each site against the mean yield of varieties at each site (Hildebrand and Russell, 1996). The mean yield then represents a type of environmental index. A site where yields are low, due either to management or to physical site characteristics is considered a poor environment, and a site with high yields is a good environment. With this definition, environment is measured as a continuous proxy variable across the range of average yields.

The technique seems especially useful in farming systems research where "farmer-managed" agronomic trials are a central part of research to design to determine whether specific technologies are likely to be adopted by farmers. In farmer-managed trials, one replication with two or more treatments is placed on a random sample of farms. Such trials include a control treatment (traditional technology) with each replication.

The environmental index is used to create recommendation domains for different environments. This allows the researcher to use both qualitative and quantitative data when examining the data.

After the identification of the primary qualitative factors the different production levels were compared by using qualitative comparisons. The combination of both the qualitative and the quantitative information therefore allowed us to identify the recommendation domains and the major factors that explained the variation in the production.

These results were then validated in focus groups with farmers. Focus groups are used to get more in-depth information on perceptions, insights, attitudes, experiences, or beliefs. Focus groups are useful for gathering subjective perspectives from key stakeholdersl, in providing interpretations of data collected through quantitative methods (quantitative data is numeric and measureable).

Focus groups are also used as a mixed method evaluation approach to increase validity of evaluation findings by using a variety of data collection techniques. The farmers were asked to explain the variation and identified the main factors impacting yield. These were compared to the results from the research.

Risk is operationalized by looking at the factors that could impact the production. This was done in the Farmer Field Schools during the trials. Are there limits to growing season length? The research team discussed with collaborating farmers the main limitations to the growing season. Its length is likely to be limited by a cold season such as winter and by the start and end of the rainfall period.

Production can also be affected by one-off catastrophic weather events, like frosts, hailstorms, rainstorms, gales, and hot dry winds. There are other catastrophic risks like locust plagues and some diseases that are more likely to occur at specific times in the year and may limit the crop season. If such events occur every year they should be avoided by having the crops at stages that are not damaged during these events.

In some perennially warm, damp areas, both starting and finishing dates may be largely under the farmers' control, but in all areas farmers can have a degree of control over season length either through farm management or choice of crop.

We examined with farmers the following:

- Could local crops yield be better if sown earlier or later? Why?
- Are crops maturing fully or are they drying off before their grain are completely filled?
- Are local temperatures too high or too low at any stage for any of the crops? When?
- Is there sufficient water available at the right times for the crops? When is it limiting?
- Is it possible to modify soil structure to enable crops to use the full potential growing season?
- Is it possible to grow one crop species after another, perhaps using shorter duration varieties, to make more productive use of the potential growing season?
- Is the land ready for planting at the start of the season?
- Is the land too dry or too wet to allow the crop to be planted at the optimal time? Can a change in tillage or planting methods overcome the problem?
- Are previous crop residues causing delays? Can they be better managed in advance, removed or incorporated or used for mulch?
- Was the previous crop harvested in time to allow planting of the current crop at the optimum date or should a shorter duration variety have been used?
- Was the previous crop harvested early to take advantage of the best market price? Would the current crop yield be more if planted early?
- Are activities during crop growth timely?
- Is it possible to modify soil structure to enable crops to use the full potential growing season?
- Is it possible to grow one crop species after another, perhaps using shorter duration varieties, to make more productive use of the potential growing season?
- Is the land ready for planting at the start of the season?

- Is the land too dry or too wet to allow the crop to be planted at the optimal time? Can a change in tillage or planting methods overcome the problem?

- Are previous crop residues causing delays? Can they be better managed in advance, removed or incorporated or used for mulch?

- Was the previous crop harvested in time to allow planting of the current crop at the optimum date or should a shorter duration variety have been used?

- Was the previous crop harvested early to take advantage of the best market price? Would the current crop yield be more if planted early?

- Are activities during crop growth timely?

These questions are intended to lead to the conclusion that two main factors determining the potential growing season are the environment and how well the plant material chosen matches the environment. Finding out which, and to what extent, these environmental, crop variety and management factors have an impact on the best use of the growing season is the first reason for doing on-farm trials. Overall the idea is to manage risk and to identify recommendations within the control of the farmers that may be utilized to control it.

Finally the team set out to establish recommendations that may increase the production in the next cropping cycle. Based on the identified factors in objective number two the team provided recommendations to resolve these problems. Once again these suggestions were validated with the farmer group with the focus group. After they identified problems they were asked to create recommendations. In this manner the recommendations from the team were compared to the recommendations from the farmers. If there were any differences, open ended questions and the farmer's opinion was sought.

RESULTS

Objective one was to determine if the average yield had increased by using the new varieties and technology package. According to the initial qualitative field reports the yields were between 175 and 225 Kg. per hectare (See Annex 1). When compared with the mean production of 510.3 Kg. per hectare (see Table 3), we can conclude that there has been a substantial increase in production.

The research team is aware of potential risks that could have impacted the new varieties (see Box 1). There is no assumption that there would be increased production and or increased risk based on potential inadequate environments (including ph., fertility, etc.) and potential damage from pests and diseases.
To understand this increase in the production CODESPA has introduced new varieties of seed (eight years validated in Angola) and a technological package resumed in the Figure 4.

Objective number two was to determine the factors that explain the variation in the production (Kg/Ha). Risk was determined by considering the agronomic factors that limit or jeopardize production. Initially we graphed many of the factors and found that the strongest similarity in the trend line was between the yield per hectare (see Figure 4) in each location and the soil type (see Figure 5). A paired-T test confirmed the relation with a correlation of 72% and a significance of 0.002 (see Table 4). Therefore we concluded that soil quality was the strongest factor.

Figure six shows the Adaptability Analysis of the Soy Production. In this case the environmental index is on Y-axis. As stated those scores that receive a score below 0.1 were considered to be poor environment and 0.1 and above were better environments. The idea is also to prepare recommendation domains.

Figure 7 shows the factors that impacted the production of the soy. In cases of the Omunga (Chikumbi) (280 Kg/Ha, EI =0.47), Katapi (359 Kg/Ha, EI = 0.60), Ussinda Katota (390.67 Kg/Ha, EI =0.65), and Chicala sede (397 Kg/Ha, EI =0.66) there was maize cultivated in 2012 and they had the lowest production and environmental indexes. These parcels were also impacted by the lack of rain because of the late planting date (see Figure 7).

Maize removes a great deal of N, P, K from the soil and will therefore impact the next crop. As a base for calculation, if a maize crop yields 40 t/ha, it removes 160 kg N/ha although peak uptake is 210 kg N/ha. Typical phosphate removal is 1.4 kg P2O5 /t fresh crop - that is 55 kg/ha P2O5 for an average 40 t/ha forage crop. Maize crops also remove large amounts of potash, Typically 4.4 kg K2O/t fresh yield which amounts to 175 kg/ha for a 40 t/ha crop. This quantity must be replaced to maintain soil fertility. Nutrient offtake is dependent on yield; a 30 t/ha removes 130 kg K2O and a 50 t/ha crop removes 220 kg/ha K2O.

There were several other cooperatives that had slightly higher production including Katapi (391 Kg/Ha, EI =0.65), Chicala sede (397 Kg/Ha, EI=0.66), Chitalela (470.00 Kg/Ha, EI=0.78), Mbanje (513.33 Kg/Ha, EI=0.85).In all cases except Katapi and Omunga (sanambelo) there was production of maize in the previous years. All were planted on a hillside and had a previous maize crop; the soil appeared to be diminished in terms of nutrients and organic material.

Inside those farms in the lower strata there appear to be two very distinct systems. In some cases there is a rotation of maize and soy, while other farmers are doing only soy but planted too late. It is important to understand this distinction because the recommendations should be different for those in different systems.

The example of Katapi (EI 0.60 and 0.65, see Figure 6) clearly exemplifies the risks associated with the soil as well rain. These two areas had production of 359 and 391 Kg/Ha (see Figure 6). One of the parcels was previously planted with maize and the other had a heavy clay soil that impacted the production on half the land. One of the areas was planted in the end of December and the other in January and the rain stopped in March. The lack of rain impacted the development of the grain and the overall yield.

Once again in the case of the soy and maize system we are dealing with a very different rotation rather than just soy. The research team expects lower production of soy in the maize and the soy system. There should, however, over time be an increase in the maize production. In essence if the research team only looks at the soy we may miss the larger picture and environmental benefits.

The case of Katapi was one of our focus groups in which we essentially listed all the production data and had the farmer's list the information. The farmer's confirmed the interpretation that was determined by the research team in terms of soil and the impact of the planting date. The exercise is important in the fact that we are not imposing potential solutions on the cooperative but rather jointly are coming to solutions. One caveat that the cooperative added is that rain can also have the opposite impact of being prolonged and impact the harvest with too much rain.

In the other cases of Omunga (EI=0.47 and 0.65, see Figure 6) and there was production of 280, and 319 kg/Ha and both were planted in January. Once again our theory about the data was confirmed in a focus group conducted with the cooperative. The group felt that the late planting date impacted the production due to a lack of rain. Furthermore this is once again a maize and soy system which seems to be destined to have lower production rates for just soy. There is some research showing soybean benefits from crop rotation with yield benefit from rotation is typically 10% or more for soybean (Pepper and Emerson, 2013). Lauer et al. (1997) found lower soy production with higher maize. The main point is that there appears to be a benefit but both crops need to be examined.

The case of EKOLELO cooperative is very interesting because we can compare so many different factors. In Keve community, the only soil considered was the "onaka", which is a soil close to the river and with a high capacity of retaining water. In this case, the lack of water in the last phase of the crop was not very serious due to the quality of the soil. The production was 977 kg/ha. In the case of Chipembe, the plant suffered the lack of water in the last period of the crop, but the good quality of the soil and the quantity of weeding made a production of 805 kg/ha. The main difference between both is based on the quantity of seed per hectare, being in Keve 35 kg and in Chipembe 25 kg were utilized. The difference may be partially explained by the planting density. A focus group was conducted to validate those conclusions: best quality of soil in Keve and more quantity of seeds were the main factors to tackle the lack of proper weeding. While in Chipembe the only factor for not having a higher production was the small density of plants.

Box 1. POTENTIAL RISKS OF IMPROVED VARIETIES:

a. Large-scale agricultural systems exhibit a poorly structured assemblage of farm components, with almost no linkages or complementary relationships between crop enterprises and among soils, crops and animals.

b. Cycles of nutrients, energy, water and wastes have become more open, rather than closed as in a natural ecosystem. Despite the substantial amount of crop residues and manure produced in farms, it is becoming increasingly difficult to recycle nutrients, even within agricultural systems. Animal wastes cannot economically be returned to the land in a nutrient-recycling process because production systems are geographically remote from other systems which would complete the cycle. In many areas, agricultural waste has become a liability rather than a resource. Recycling of nutrients from urban centers back to the fields is similarly difficult.

c. Part of the instability and susceptibility to pests of agro ecosystems can be linked to the adoption of vast crop monocultures, which have concentrated resources for specialist crop herbivores and have increased the areas available for immigration of pests. This simplification has also reduced environmental opportunities for natural enemies. Consequently, pest outbreaks often occur when large numbers of immigrant pests, inhibited populations of beneficial insects, favorable weather and vulnerable crop stages happen simultaneously.

d. As specific crops are expanded beyond their "natural" ranges or favorable regions to areas of high pest potential, or with limited water, or low-fertility soils, intensified chemical controls are required to overcome such limiting factors. The assumption is that the human intervention and level of energy inputs that allow these expansions can be sustained indefinitely.

In general the majority of the risk came from very poor or tired soils due to previous production of maize. When coupled with the water from rain the research team feels that we have identified the primary sources of risk that also impact production. These factors are also controllable by altering some planting methodologies.

A third agronomic factor that increased risk that was not mentioned but has been a concern of the project is the importance of weeds. Weeds have an important negative impact on the production of soy. Weeds were witnessed to be competing with the soy and were not eliminated during critical time periods. Jannink et. al. (2000) reported that root and shoot interference are the main factors that cause soybean yield reduction. Weeds that germinated at the same time as soybeans grow faster and maintain a canopy above and below the top of the soybean canopy. Therefore they intercept photosynthetically active radiation (PAR) at the expense of soybeans. This results to elongation of soybean stems with a decrease in diameter, causing lodging. Soybean are not strong competitors in the early part of the season, therefore weeds outgrow them. If the crop is not kept weed free, light competition takes place after 4 weeks when the weed grows taller than soy beans and intercepts photosynthetically active radiation PAR (Jannink et. al., 2000).

There were alsorisk of some attacks by insects. Late planting, on the other hand, may have exposed the crop to attack by some late season pests and also deprives the crop of sufficient moisture if the rains stop early. Insect pests of soy bean occur sporadically and can become economically important when large numbers build up. In this case we had an attack of Aphids in Bie that destroyed around 1% of the crop area. In the case of Keve the attack from rabbits that damaged around 2% of the crop.

Regular inspections of the fields are necessary in order to facilitate the timeouts identification of insect pests and animals.

Soy beans are susceptible to various insect pests, which have a negative effect on yield and on the quality of the grains. Insect control is necessary when pods are damaged. Certain soy bean cultivars are susceptible to root knot nematode; and the cultivation of these cultivars in soils with a high risk of nematode is not recommended. During the seedling stage, plants are attacked mainly by cutworms and large false wireworms. It is important to have the correct identification as well as effective control of insect and animal pest infestations.

MEAN YIELD OF IMPROVED VARIETIES				
N	Minimum	Maximum	Mean	STD. Deviation
15	240	980	510.3	242.23

Table 3. Mean Yield of Improved Varieties.

TRADITIONAL ACTIVITIES AND TECHNOLOGICAL PACKAGE

STAGES	CURRENT ACTIVITY	PROPOSED ACTIVITY	OBJETIVE OF THE PROPOSED ACTIVITY
Initial diagnostic	No activity	Crop-ground History	-To determine incidence of pests and diseases -Level soil fertility
Land preparation	Land preparation in April-May	Before planting, you need to prepare the land	Elimination and/or reduction of competition Reducing work-weeding
Fertilization	-Fertilize with 12-24-12, not quantity test	History of the land-Quick-determination tests fertility level	-Determine whether it is necessary or not fertilize -Determine based on the level of fertility.
Seed selection	Between Rows: Varies from 40 x 40 cm. To 1 meter x 1 meter	Between Rows: 40x40 cm Assessing the degree of germination after 8 days: less than 80% need reseeding	-Animal traction: 40x40 -Tractor and manual: 60x60
	Between plants	15x15 cm	-Standard density to simplify recommendation and minimize competition
	Depth:	Depth: 5 cm	Allow good germination
	Number of seeds / seed point: 3-11	-Number of seeds 1 (Requires reseeding) -Number of seeds: 2 (Requires removal of plants)	-To increase the area of development of each plant and to increase productivity
	Reseeding: No Reseeding	Assessing the degree of germination after 8 days: less than 80% need reseeding	
	Elimination of Plants: No	-Elimination of double plants and replanting of empty at 8 days	-Ensure adequate plant population/ha
Monitoring	No information	-If possible 1/week: Pests and diseases	
		-Weeds: Control at 15 days after sowing	-Avoid competition for nutrients, light, water, and other factor
Fertilization 12-24-12	12-24-12	-Determine whether it is necessary or not: -Diagnosis -History -Development of Cultivation (force) -If necessary, use only UREA, not 12-24-12	-Avoid unnecessary expenses60
Harvest	Harvest-Time: Color change of	-Time of Harvest: Color change pod of 50%	Avoiding losses in field-

Table 4. Comparison of traditional activities and technological package proposed by CODESPA.

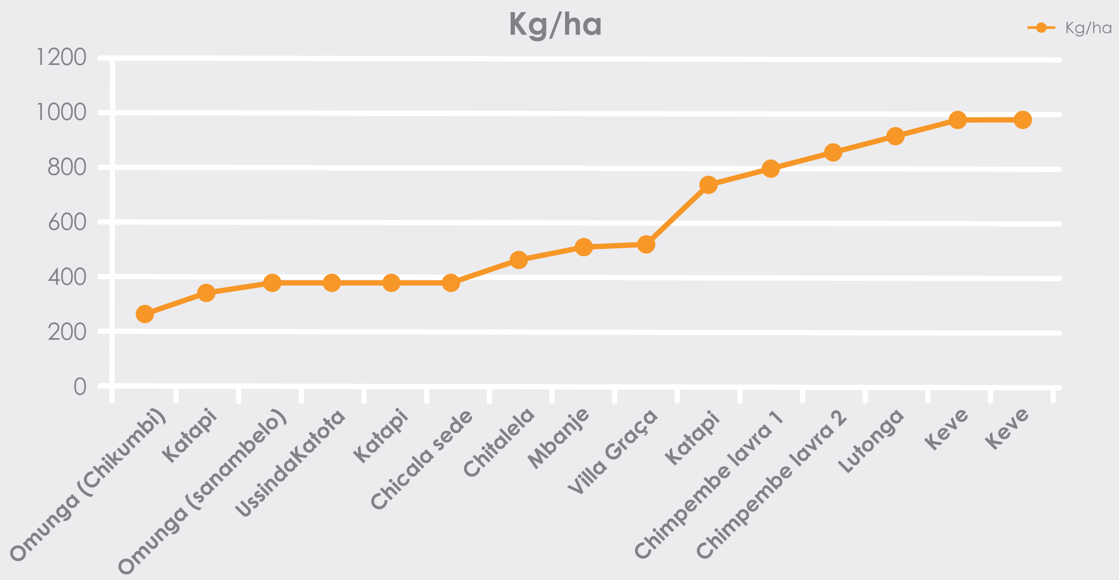

Figure 4. Yield in Kg/Hectare in the Different Communities.

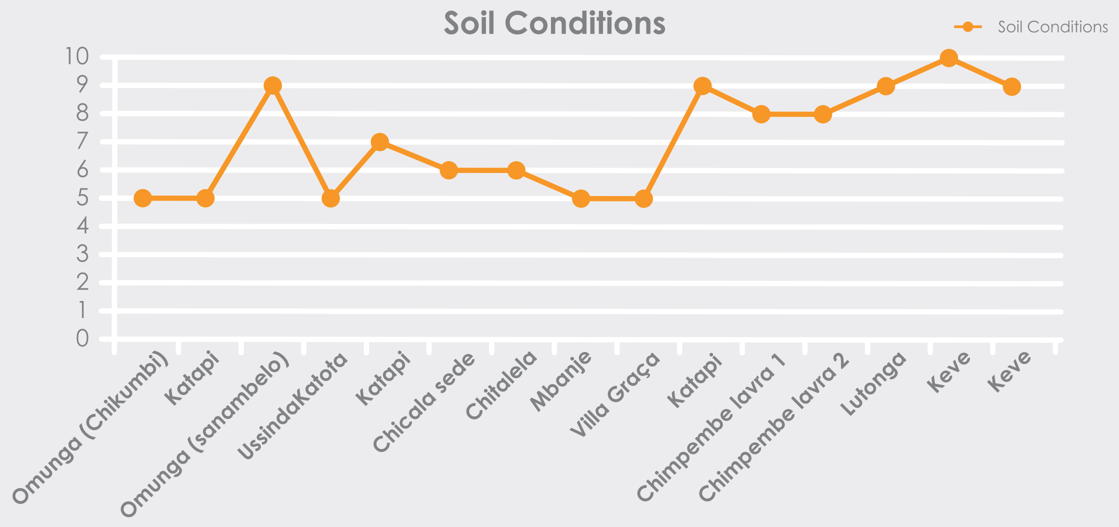

Figure 5. Quality of the Soil in the Different Communities.

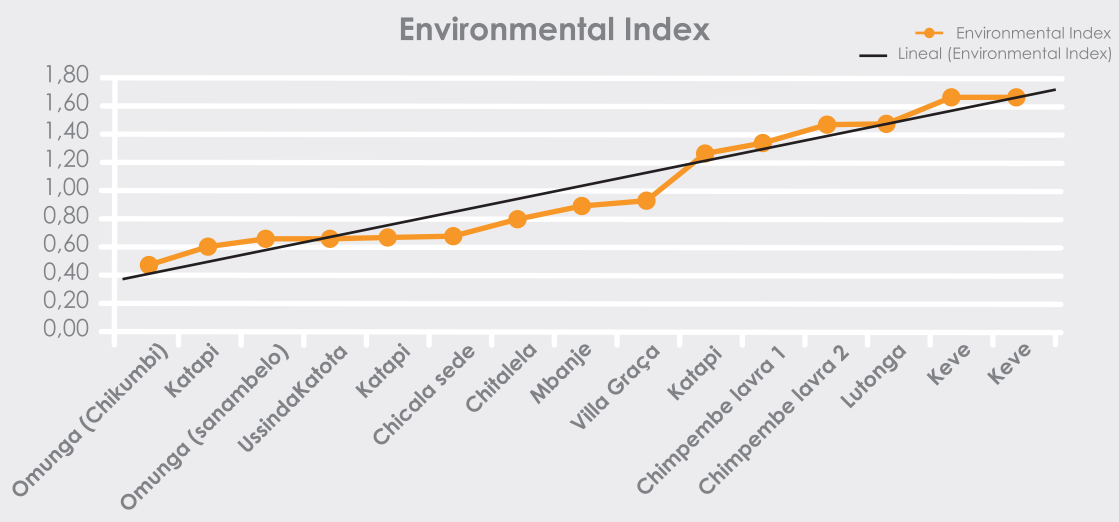

Figure 6. Adaptability Analysis for the Production of Soy in Kg/Ha per Cooperative.

PAIRED T-TEST BETWEEN YIELD AND QUALITY OF THE SOIL				
	MEAN	N	SD	STD ERROR MEAN
Yield	510.03	15.00	242.23	64.74
Quality of the Soil		15.00	1.72	0.46
		N	Correlation	Sig.
Correlation between Yield and Quality of the Soil		15.00	0.72	0.02*

*p>.05

Table 5. Paired T-Test between Yield and Quality of the Soil.

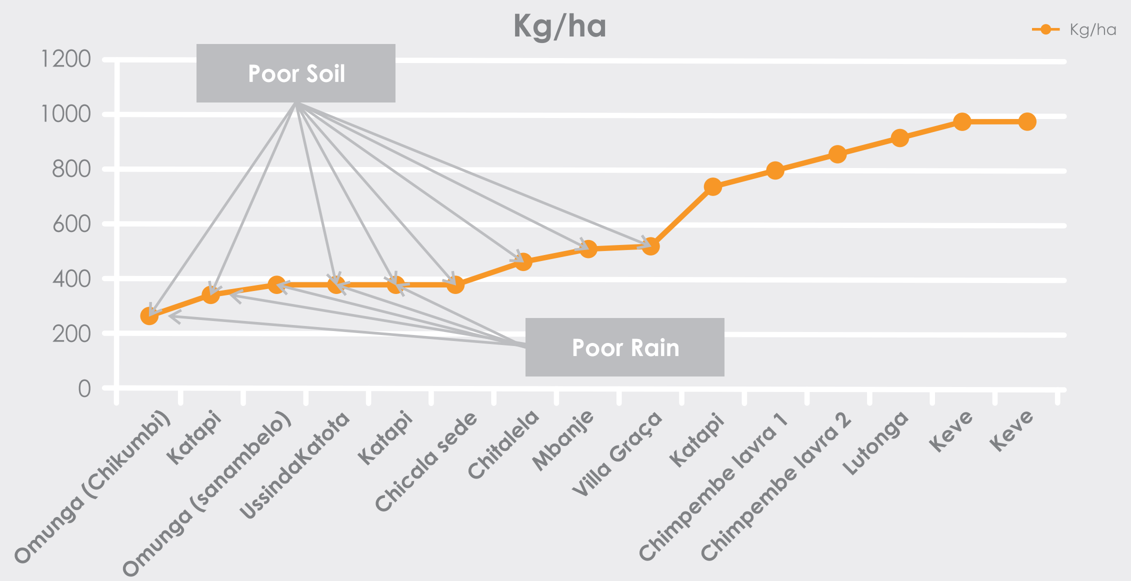

Figure 7. Production of Soy in Kg/Ha per Cooperative.

Box 2. IMPACTS OF INCORPORATING CROP BIOMASS IN THE SOIL

While the stem and leaves grow upward, the root system continues to grow deeper into the soil. Initially, the plant produces a main taproot, but soon after emergence numerous lateral roots branch off to produce a fibrous root system. The deepest roots may reach down five feet (1,5 meters) or more in loose, well drained soils, but most of the roots are found in the upper one foot (30 cm) of the soil.

The young roots will develop root nodules within a week after emergence. The nitrogen-fixing bacteria, called Rhizobium, enter the nodules and after ten to fourteen days are able to supply most of the plant's nitrogen needs. In favorable soil conditions, about two dozen nodules will develop on the upper roots of a plant. Healthy nodules are pink or reddish inside.

Box 2. IMPACTS OF INCORPORATING CROP BIOMASS IN THE SOIL

The amount of nitrogen returned to the soil during or after a legume crop can be misleading. Almost all of the nitrogen fixed goes directly into the plant. Little leaks into the soil for a neighboring non-legume plant. However, nitrogen eventually returns to the soil for a neighboring plant when vegetation (roots, leaves, fruits) of the legume die and decompose.

When the grain from a grain legume crop is harvested, little nitrogen is returned for the following crop. Most of the nitrogen fixed during the season is removed from the field. The stalks, leaves, and roots of grain legumes such as soybeans and beans contain about the same concentration of nitrogen as found in non-legume crop residue. In fact, the residue from a corn crop contains more nitrogen than the residue from a bean crop, simply because the corn crop has more residues.

A perennial or forage legume crop only adds significant nitrogen for the following crop if the entire biomass (stems, leaves, roots) is incorporated into the soil. If forage is cut and removed from the field, most of the nitrogen fixed by the forage is removed. Roots and crowns add little soil nitrogen, compared to the above ground biomass.

RECOMMENDATIONS

The final goal was to establish recommendations that may increase the production and minimize risk in the next cropping cycle. One of the primary concerns was the condition of much of the soil and its impact on the overall production. In order to maximize the soy production and minimize risk the research team was thinking about avoiding areas planted with maize.

Based on the previous discussion on the benefit of the incorporation of the root in the soil, we **recommend cutting the plant rather pulling it out. One of the key recommendations will be to move the date to start the seed bed between the 15th of November and the 15th of December**. The planting date is one of the most important decisions by which risk may be controlled. Planting too early is dangerous because a prolonged dry spell after planting may result in permanent wilting of the crop and the need for replanting. Moreover, early plantation means early cropping and this would difficult seriously the drying process for the small farmers. Late planting, on the other hand, may expose the crop to attack by some late season pests and also deprive the crop of sufficient moisture if the rains stop early. The key is to plant soybean between the fifteenth of November and the Fifteenth of December, in order to have enough rainfalls and finish the crop with the rainy season.

Another recommendation is to reduce the distance between rows to reduce weed growth. Ideally, it would be 0.70 cm between rows and 0.25 cm between plants and 2 seeds per hole. Currently farmers are planting as much as one meter between rows and the distance varies between plants. An important goal is stand uniformity. The 'rule of thumb' is that the soybean canopy should completely close (cover and shade the space between rows) by flowering time. The faster the soybean canopy closes, the fewer the number of weeds will grow. In narrow rows, weeds cannot be cultivated easily.

Another recommendation to manage risk is to create a buffer between the field and grasses that could host wildlife and viruses. Information from precision-farming technology indicates that field edges located next to mature woodland may suffer at least a 30 percent reduction in yield, making these areas unprofitable to plant, fertilize, treat with pesticides and harvest. This yield loss may be greater during drought years.

Another recommendation is the training of farmers in traditional systems for insecticidal and repellent rodents and rabbits. Botanical insecticides have long been touted as attractive alternatives to synthetic chemical insecticides for pest management because botanicals reputedly pose little threat to the environment or to human health. Currently there are almost no natural insecticides being used in Huambo or Bie. Pyrethrum and Neem are well established commercially, pesticides based on plant essential oils have recently entered the marketplace, and the use of rotenone appears to be waning. A number of plant substances have been considered for use as insect antifeedants or repellents, but apart from some natural mosquito repellents, little commercial success has ensued for plant substances that modify arthropod behavior. In the context of agricultural pest management, botanical insecticides are best suited for use in organic food production and with small producers. These plants can play a much greater role in the production and postharvest protection of food in developing countries.

DISCUSSION

The main goal of this research was to examine the productivity of soybean and come up with recommendation that can maximize production and minimize risk in five cooperatives.

We can never forget we are working inside an environment where risks have to be minimized. Family agriculture has to be understood with a systemic approach that combines many different activities to supply familiar demands. Soybean is just one of those activities. The way we get to involve it in that system and that environment will mean the success of the whole project.

This outcome pursues the improvement of productivity (a greater production per cultivated surface) and production (greater production in absolute terms) of the farmers in the target cooperatives.

In this sense, activities are being implemented in order to improve the agricultural practices concerning the soybean crop, by means of the Farmer Field School (FFS) methodology, which aims to guarantee the dissemination and replication of best agricultural practices among the cooperatives in the intervention areas.

For this reason, it is important to define, from the beginning of the design phase, the endogenous and exogenous environment of the farming systems within which the technological alternative is being modeled. A precise description of the target farmers, decisions and assumptions made with respect to the key determinants of the expected performance of the interventions, vis-a-vis the traditional practices, results in a clear statement of what the proposed technological change is, what type of farmers and production system it is designed for and what conditions (ecological, physical and socio-economic) it is suitable for. This paper deals with the agronomic phase of these system rather than many of the social issues **5**. These are the basic hypotheses to be evaluated in the testing phase, and which are particularly significant for extension purposes. Consequently CODESPA project extensionists can make an effective contribution in addressing these issues and understanding their broader implication.

We have laid out a theoretical framework based on the current cropping systems and the typology of the farmers. This theoretical framework was chosen because one of the goals of the research is that it is transferable to

5. The project deals with many of the social issues in many other phases. This paper just deals with some of the agronomic portions of the farming system.

those farmers that are in most need. In this case those farmers are the small subsistence farmers with limited resources, those that are female headed and have to walk 12 km to arrive, as well as those that have no cash to invest.

Currently the project is working with farmers with more resources. The research team, however, are trying to develop technologies that fit into the entire system. Furthermore we are trying to minimize risk. Consequently, it is critical to identify the specific circumstances and causes of variation and loss when it occurs.

Risk is never eliminated; however, we try to manage it with considerations that examine the whole system. It would be easy to recommend closing the planting space even more to increase productivity. Currently many other private mechanized have a much higher production per Hectare. If we factor in the per plant benefit, the small producers of this project are producing just as much. This is done without the much higher costs which include fertilizer and fungicides would suppose. For the current system it is better to minimize risk at the potential benefit of per hectare increases to three tons.

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