Cotton Production in Uganda:
Would GM technologies be the Solution?

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Abstract

The government of Uganda is currently testing the performance of genetically modified (GM) cotton varieties. Cotton is cultivated in Uganda for two main reasons: 1) agro-ecological conditions favor cotton cultivation, and 2) there is a long tradition of cotton cultivation in the country. Two main research questions are addressed in this study: a) would the adoption of genetically modified (GM) cotton benefit Ugandan farmers? b) Would the use of GM seed be more profitable than the low input traditional system or than the organic production system? Stochastic budget analysis is used to address these questions. The results show that estimated values of cotton profitability do not seem to justify the investment in a complex technology. The question then is how transferable is GM technology and how easily can it be adopted by Ugandan farmers. The vertical integration of the chain could facilitate the dissemination of the technology, but availability of seed and inputs of good quality and appropriate extension support have to be guaranteed.

Keywords: Stochastic budget analysis, GM cotton, Organic cotton

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Cotton Production in Uganda:

Would GM technologies be the Solution?

The government of Uganda is currently testing the performance of genetically modified (GM) cotton varieties. Confined trials of insect resistant (IR) cotton varieties have been implemented in two selected sites. Herbicide tolerant (HT) cotton is waiting for approval from the Uganda National Council of Science and Technology (UNCST). Despite a long cotton cultivation tradition, cotton productivity in Uganda is very low compare to international averages (900 Kg/ha). In 2005 cotton yield was around 152 kg/ha, one of the lowest in the world. The government has recognized the potential of genetically modified (GM) cotton to improve cotton production and thus producers' livelihoods and the economy in general. Decision makers agree on the importance of understanding all benefits and risks faced by the different actors involved in the cotton value chain with the adoption of this technology.

Two main research questions are addressed in this study: a) would the adoption of genetically modified (GM) cotton benefit Ugandan farmers? b) Would the use of GM seed be more profitable than the low input traditional system or than the organic production system? While numerous studies have been published on cotton in Africa, relatively few have attempted to assess in quantitative terms the potential impact of GM cotton.

1. Why Cotton Production in Uganda?

Cotton is cultivated in Uganda for two main reasons: 1) agro-ecological conditions favor cotton cultivation, and 2) there is a long tradition of cotton cultivation in the country. The crop was introduced in 1903 and was initially grown only in the Central Region but eventually it spread to the rest of the country. Together with coffee became the most important source of revenue for the government from the 50s to the 70s. During the social unrest period of 70s the crop was abandoned, productivities and areas cultivated dropped dramatically. In the late 1980s the government initiated a program to provide extension services, tractors, and other inputs for cotton farmers. Ginneries were rehabilitated and producer prices increased. In 1994 the government of Uganda in collaboration with the World Bank (WB) implemented a cotton sector development project. There has been some recovery in production levels; however cotton still only accounts for 2 to 5% of Uganda's exports, compared to 25% in the 1970s (Serunjogi et al. 2001).

The situation that cotton producers face now is however different than in the 70s. To begin with, Uganda does not longer have a premium price for the cotton quality. Albeit there is only one variety of cotton in cultivation the lack of uniformity of the cotton lint caused the lost of the premium price in 2002. While environmental and soil properties favor the development of the crop pretty much all over the country, climatic conditions have contributed to the slow recovery of the sector. Drought periods follow by excessive rain, low temperatures and cloudy weather are considered primary causes of low cotton yields. Recent increases in productivity has been the result of purification of cotton types by the National Agricultural Research organization (NARO), credit facilities and input distribution to farmers by the Cotton Development Organization (CDO), and improvement in agronomic practices through extension work.

Despite that farmers admit that cotton is not a profitable business they keep cultivating it. The reasons argued are multiple; the most common one is lack of alternatives. The certainty that cotton producers will have a buyer is probably another strong argument for cotton cultivation. Seed and inputs are usually distributed by the ginneries that demand in exchange rights over the harvest. In general, a falling in cotton planted acreage is a dominant trend in Uganda (UEPB 2007). In recent years rice production has come out as a better economic activity for farmers. This is specially the case for areas located in the Eastern Regions. In more marginal areas like the northern districts cotton is still one of the few alternatives left to farmers.

As an alternative to conventional production, organic production has been adopted in some areas of Uganda already distinguished by their low input use. In the 2007/08 season about 50% of the cotton areas embark on en-mass promotion of organic cotton production. Due to lack of proper training and availability of inputs the pest incidence caused the loss of about 68% of the yield in these areas. As a consequence organic production only represented 20% of the national production for the same period (CDO 2008). The most important area of organic cotton production is located in Lango. This area is characterized by low use of chemical inputs. As any other organic agricultural system, the Lango system is characterized by use of biological control and cultural practices to deal with pest and diseases, limited use of productivity-enhancing technologies, and certification of the whole farming system and individual ginneries. In Lango cotton is produce is rotation with sesame, an oil seed crop that has a much higher productivity and price in the market. Farmers do not have many alternatives to cotton in this rotation system. Basically the entire organic cotton production is for export

2. Methodology

2.1 Stochastic Budget Analysis

In order to evaluate the profitability of cotton production at the farm level we used the basic partial budget analysis augmented with stochastic simulations. Survey data was collected to estimate the marginal returns to cotton production for organic and conventional producers and as well for low input and high input producers. A low input farmer basically only uses a very limited amount of chemical pesticide. Fertilizer application does not seem to be a common practice in the study sites in Uganda, therefore farmer using fertilizers and pesticides were classified as high input producers. This information combined with data from published sources was used to predict the marginal returns of IR cotton and HT cotton. An additional scenario that combines organic production with GM seed was also developed. The simulations were developed using @Risk software (an add-in to excel).

The comprehensive guide produced by CIMMYT (1988) was used as the basis for calculating partial budgets and simulating the profitability of cotton production. Expected total income, total costs, expected net income and net return to investment were calculated per acre. Cotton seed is distributed free of charge and thus the value is zero for the producer. Total use of chemical and organic fertilizers and pesticides were reported by farmers and converted to values per acre. The value of the land was accounted only for those farmers that rented land. Similarly only hired labor costs are included in the budgets. Average wages paid to hired labor were used to estimate the total family labor costs. This assumption seems reasonable in the production areas studied, where labor markets are active and farmers produce the crops commercially. Male and female labor days were valued equally. There was no evidence available to justify valuing them differently.

2.2 Simulations

The scenarios simulated were IR cotton and HT cotton. A seed price difference is expected for GM seed, but the absolute value of this price difference varies widely according to the technology provider and its market power. Cost savings associated with the use of GM seed use are represented by the reduction in insecticide and herbicide applications and/or labor costs related, if any. Assumptions used in partial budget scenarios are summarized in Table 1. In order to account for the risk and uncertainty of agricultural production some of the parameters were replaced by distributions. The distributions used in our study were based either on literature review (e.g. technology fee, abatement effect, and pesticide and spraying costs reduction) or on the primary data collected from farmers (e.g. yield variability within and across farmers, yield loss due to constraint, price fluctuations, pesticide, and spraying).

We used @Risk software to estimate candidate distributions and select the one that best fit the information collected in the survey. We selected distributions that best fit the triangular distributions elicited from farmers under 3 scenarios: 1) without the constraint, 2) with the constraint but without using insecticides, and 3) with the constraint and chemical control of the pest. In @Risk, we drew from the sample distributions of the each yield parameter (minimum, maximum, mode) to generate yield variability both within and across observations.

Yield losses due to targeted constraints were derived from the elicited yields:

$$E(Y_{loss}) = \frac{\left[E(Y_{c=0}) - E(Y_{i,c=1})\right]}{E(Y_{c=0})} \quad (5)$$

$E\left(Y_{loss}\right)$ is the expected yield loss ratio, $E\left(Y_{c=0}\right)$ is the expected yield without the constraint, $E\left(Y_{c=1}\right)$ is the expected yield with the constraint, and *i* indicates use of insecticide (1 if farmers use insecticide or 0 otherwise). Based on expected yield losses, expected damage abatement with insecticide can also be estimated as:

$$E\left(Y_{abat}\right) = 1 - E\left(Y_{loss}\right) \quad (6)$$

While actual damage and damage abatement are variables that are difficult to estimate, this represents a fair approximation of damage abatement. Yield losses reported by farmers tend to be upward biased because it is difficult for farmers to single out the effect of any individual pest. With respect to estimating abatement of yield losses, often farmers relate stronger pesticide effects with higher doses of pesticides.

Best-fit distributions were also used for variables that were easy to obtain from farmers: 1) output price, 2) pesticide cost, and 3) spraying cost. Triangular distributions, on the other hand, were used to model variables that measure: 1) technology efficiency (trait expression), 2) the technology fee, 3) reduction rates in pesticide use, 4) reduction rates in spraying costs for the case of IR cotton, and 5) increase rate in herbicide use for the case of HT cotton. Explanation on minimum, mode, and maximum values adopted for all these variables are reported in Table 1.

The technology fee was expressed as a percentage increase in assumed seed price, since the seed is distributed for free. The assumed seed price is derived from information provided by the Cotton Development Organization (CDO)[4]. The technology fee is a sensitive issue because the price of GM seed will affect its adoption. Other estimates in the literature about biotech crops have reflected the temporary monopoly conferred in this capital-intensive innovation through intellectual property instruments (Falck-Zepeda et al. 2000; Moschini and Lapan 1997). We speculate that the public sector would probably tend to charge lower technology fees than the private sector.

2.3 Data Collection, Sites and Sampling

A survey instrument was implemented to collect information on cotton production and current practices used. In addition to the input use and production questions, the survey included elicitation on subjective yield distributions from growers in order to gauge farmers' perception to the extent of yield losses caused by bollworm and by weeds. The triangular distribution (minimum, maximum, mode) is the simplest distributions to elicit from farmers, approximates the normal distribution, and is especially useful in cases where no sample data are available (Hardaker 2004).

[4] CDO is was established by an Act of Parliament in 1994, regulates, coordinates and promotes all the aspects of the cotton sub-sector in the country

Lira and Kasese are the districts where the confined trials have been implemented and they are also the districts selected for evaluating the current cotton production systems and conduct our household interviews. After identifying cotton producing, we randomly selected villages with farmers cropping cotton in the 2006 and 2007 seasons, 3 in Lira and 7 in Kasese. The distribution of villages followed the proportion of cotton produced in the areas but it also intended to have a good representation of organic producers.

A total of 150 household heads were interviewed, 48 producers in Lira and 102 in Kasese. The households were randomly selected from the list of producers provided by ginneries operating in each region. The questions were addressed for the 2007 campaign, and some additional information was collected for 2006. In some cases selected producers cultivated more than one plot. The information was analyzed per plot for the 2007 season only, and plots with incomplete information were not considered in the analysis. Thus the total number of observations in our analysis ended up being 151, of them 35 are plots from producers from Lira (12 organic producers) and the rest are plots from producers in Kasese.

3. Understanding the Cotton Chain

3.1 Seed chain

Cotton value chain depends on the availability of seed and the quality of it. The need for improved varieties and certified seed is probably the most important constraint encountered in cotton production in Uganda (Serunjogi et al. 2001). Uganda cotton production is characterized by the use of a single variety (Bukalasa Pedigree Albar or BPA). The main actors in the cotton seed chain are cotton producers, the National Agricultural Research Organization (NARO), the Cotton Development Organization (CDO) and some private ginneries. NARO coordinates and oversights all aspects of agricultural research. As such this institution is in charge of research, breeding and technology development in the cotton sector. NARO and the institutions that preceded it were relatively active in selecting and releasing improved cotton varieties. The multiplication and seed distribution process however needs more attention. The seed that farmers use is entirely channeled through the ginneries, NARO and CDO.

CDO regulates, coordinates and promotes all the aspects of the cotton sub-sector in the country (Figure 1). CDO also monitors cotton production and marketing and provides policy advice regarding the crop (CDO 2006). The basic cotton seed is developed by NARO but multiplied by the CDO and mainly distributed to the ginneries for commercial multiplication and distribution to farmers. CDO is also in charge of determining and fixing the cotton price given to farmers. Usually this price is set at 60 – 65% of the World Market price. The price that farmer receives however can vary considerably depending on the region and time of the year.

The ginneries are around 57 in number and they are privately owned by approximately 36 different companies. Given the irregular cotton production ginneries compete for access to cotton areas. The ginning capacity of the country is however limited and the operating ginning machines are of poor quality. Ginneries are obliged to give the seed of good quality back to CDO and use or sell the rest to oil and milling companies.

CDO makes a rough estimation of the seed volume needed for the following campaign. CDO is also responsible for de-linting, grading and dressing the seed that will be finally given to ginneries for distribution. Availability of cotton seed is a very limiting constraint for improving cotton productivity in Uganda. According to UEPB (2007) cotton exports in 2006 fell 29% in comparison to the previous year. Among other factors, the low performance in 2006 was related to late planting, but mainly to the use of ungraded fuzzy seed (not de-linted) leading to high seed wastage and the increased cost of provision of planting seed. The CDO has intervened supporting efforts in the de-linting and seed grading.

3.2 Product Chain

Farmers, intermediate agents and ginners/exporters are the main actors in the cotton[5] value chain (Figure 1). Producers obtain the seed from the ginners. Very often ginners also provide farmers with fertilizers and pesticides. Farmers pay back at harvest either with cotton or cash. The level of inputs use is however still limited and often farmers decide plant cotton only because of the secure market and fixed price. In the Northern part of the country there are very limited alternatives to cotton, either as a single crop or as part of a rotation.

At harvest, farmers could bring their production to the ginneries but often the volume produced is reduced and it does not justify paying for transport. Most commonly, intermediary agents gather the production of several producers and bring it to the ginneries. These agents can either work for the ginnery or be independent. Originally there were restrictions on the production areas that a ginnery could cover and ginning companies were allowed only processed the cotton produced in the neighboring areas. Currently, farmers can sell their production to any agent offering the best price. This has increased the competition among agents and ginneries.

While the cotton production in Uganda does not cover the ginning potential and most companies work with excess capacity, most of the machines are rather old and the quality of the turnout is low. Ginning companies that have diversified their production and produce oil and soap remain active during the year. Most of the lint is then exported to external markets like Dubai and

[5] Value chain is composed of the product and the seed value chain. In this study we discussed only the product value chain.

Kenya, either by the same ginning companies or by other international dealers. Around 10% of the lint produced remains in the Uganda for the local textile industries.

4. Is Cotton Profitable?

The basic statistics of the household characteristics and production variables are presented in Table 2. The results are disaggregated by district. The table shows that household characteristics are comparable across districts, but some production variables behave significantly different. Age of the household head, level of education, household size and household composition is relatively similar across sites. Neither is there significant variation concerning land value, labor use, and years of experience in cotton cultivation. In average farmers interview have more than 14 years working on cotton.

The size of the cotton plot tends to be larger in Kasese. Similarly seed cotton yield and total benefits generated from cotton production are also higher in Kasese. These results correspond to what have been reported by local institutes. On the other hand it seems that the susceptibility to cotton bollworm is higher in Kasese than in Lira, implying that Bt-cotton could have a higher success in the Western than in the Northern region.

It is important to point out that the cotton plot can be managed by another person and not necessarily by the household head. So, while the percentage of female household heads in our sample is considerably low (3% in Lira and 9% in Kasese), the share of plots managed by women can be as high as 50% in Kasese and 29% in Lira. Nevertheless, when tested for mean differences between plots managed by men or women, none of the variables included in Table 2.

4.1 Traditional System

Table 3 presents results for partial budgets for low input and the high input cotton cultivation systems. High input system in the current report does not refer to an ideal situation but rather to farmers that use chemical fertilizers and more than the average amount of pesticides. From a total number of observations (151) only 27 qualified as high input users. Most of the farmers use some type of chemical control to deal with insect pest, relatively few make use of fertilizers and almost none of them use herbicides. This last input could contribute significantly to improve the profitability of the crop. Cotton is a labor-intensive crop and it represents more than 50% of the total production costs. Most of the labor is used for manual weeding. Weed infestation is therefore another severe constraint in cotton production. In our sample, weeding represents 20% of the total labor costs for both types of producers. Similar patterns are reported by other institutions working in cotton in the area[6]. Productivity of seed cotton for our sample (around 800 Kg/ha) is above the reported national average (around 400kg/ha) but the benefit costs ratios estimated are still considerably low[7].

Farmers in Kasese and Lira seem to have serious problems with bollworm. In average this pest can cause damages for more than 70% of expected output. These estimations are based on farmers' perception and may have an upward bias, but they are a good reference to understand the severity of bollworm infestation in these regions. In addition to bollworm, there are other common biotic stresses such as aphids, Lygus spp. (a sucking type insect) and cotton strainers. This biotic constraint combined with high price variability and the unreliable availability of inputs makes

[6] Agricultural Productivity Enhancement Program (APEP), personal communication, 2008.
[7] FAOSTAT average for seed cotton for the last 5 years is around 417 Kg/ha, last 10 years is around 347 Kg/ha (FAOStats, 2009).

cotton production a very risky activity in Uganda. The estimated downside risk (above 40%) for surveyed farmers illustrates the magnitude of the downside risk in Uganda.

Note that in the survey's estimates for labor costs family labor could be underestimated since it is difficult for farmers to recall and give values to family labor employed. Looking at the main costs components, it is evident that farmers invest very little amounts on fertilization. Most of the producers interviewed belong to the category "low-input-users" and while they do use pesticides to control for Lepidoptera and other main pest (Lygus spp., aphis, etc), the amount of pesticide used is definitively below standard recommendations. On the other hand the "high-input users" reported not only higher yields but also higher prices paid for their cotton. An OLS regression shows that this difference in price is statistically significant and that the main determinants are most likely to be 1) the use of chemical pesticides to control other pests than lepidopterans, and 2) the accessibility to seasonal roads[8].

4.2 Organic System

One of the purposes for the implementation of household surveys in Lira was to cover a representative number of organic producers and collect information in order to generate a standard partial budget for an average organic cotton producer. Based on the information collected, merely12 producers of 35 interviewed qualify as actual standard complying organic producers. The rest of the producers admitted using some level of chemical control to deal with heavy pest infestations. The number of organic farmers changes year to year as farmers appear to switch from conventional to organic with relative freedom. According to Dunavant, in the 2006-07 season, 11,691 organic farmers were registered and contracted for a total production of 6,600 bales (of about 185 Kg), which accounted almost one third of Dunavant production. During the 2008/9

[8] This information is available upon request.

season there were serious problems with the production of organic cotton as army bollworms infested the crop.

While it is not possible to make statistical inference based on a small number of observations, the analysis of the household surveys information can provide some useful insights. It is well known for instance that the profitability of organic cotton is considerably low (Ogwang, *et al.* 2005). For the sampled farmers the margin benefits are less than 5% of total costs. In addition to that, the downside risk -the risk of not being able to cover at least the production costs- is higher than 50%.

As conventional production, organic cotton faces several biotic and abiotic constraints. Surveyed farmers report that the damage caused by bollworm is above 50% (Table 4). A main cost in organic cotton production is labor (58%). As any other organic crop, cotton requires significant amount of labor for manual activities, including insect and weed control. Notice that, the number of farmers effectively applying organic practices is lower (N=12) than the number of farmers registered as organic producers. During field observations it became clear that some organic farmers were so desperate because of poor yields due to pest attack that many applied pesticides even if they were not supposed to.

5. Would GM cotton be the solution?

In order to estimate the potential profitability of GM cotton four partial budget scenarios were simulated. The first scenario is an organic production assuming a 12.5% price premium (half of the price premium that organic companies acknowledge paying to farmers). The second scenario simulates a hypothetical case where it is possible to use Bt-cotton seed in an organic system. The third and fourth scenarios illustrate the case of Bt-cotton and HT cotton adoption. The profitability of cotton production is very low for all the scenarios simulated. Also, none of them show first degree stochastic dominance over the others. The implication of not having a scenario dominating the others to a first degree is that none has an outcome that is clearly better in average than the rest.

The use of GM seed may reduce the downside risk, but this depends on the effectiveness of this technology to control the constraint (e.g. expression of the trait). Experts report that yield losses due to bollworm could be as high as 80% and this is in agreement with what farmers have reported (in average around 76%). Given these high values attached farmers' perception on yield losses due to Bollworm attack and weeds infestation, it is not surprising that the margins are higher for both the IR cotton and the HT cotton scenario. Perceptions however are usually upwards biased given that it is rather difficult for farmers to isolate the effect of one constraint. The marginal benefits of using GM seed therefore are directly related to the level of incidence of the productivity constraint and the actual damage caused by the biotic constraint.

In the case of the HT cotton scenario the assumptions are based on expectations. This scenario is the one reporting the highest B/C ratio and the highest marginal rate of return over low input or organic productions. Unfortunately this is also the weakest scenario due to the lack of technical information (ex. number of weeding sessions avoided with 1 application of Round-up, more accurate yield loss due weeds, relatively low number of respondents, etc). The impact of Bt-cotton has been more thoroughly documented.

The possibility of receiving a price premium is a good incentive for farmers, who already use very low inputs and no chemical pesticides, to move to organic cotton. According to public sources the premium that organic producer receive can be as high as 20% (ACE, 2007).The prices reported by farmers in Lira however do not seem to be considerably higher what conventional producers get. In Table 5 the third column includes a scenario with a 12.5% price premium, improving the profitability of cotton. Ogwang et al. (2005) performed an evaluation of organic cotton production in Lango, an important organic production area in Uganda. The evaluation included a partial budget comparison across systems: traditional, low input, high input and organic. The results of this evaluation show that low and high input systems perform much better than either the traditional or the organic system. Even considering the price premium for organic cotton the rate of returns are much higher for farmers that make use of chemical inputs. Our results however show that given the current practices in Lira, organic producers might have a slightly higher margin than high-input users if they get a premium price. However, organic producers do not seem to be getting premium prices for their produce. If there is no price premium, then there are no marginal returns that will provide incentives to farmers to move from low input production to organic production. If there is premium price, marginal returns are comparable to the ones generated by adopting Bt-cotton adoption.

Figure 2 shows the main factor affecting the profitability of the different management systems: low input, high input, conventional, organic, Bt-cotton, and HT cotton. Across all the scenarios the variability in yield and the high labor costs are the main determinants of the margins generated. A technology that contributes to reduce this yield variability would definitively have an impact on farmers' welfare.

6. Policy recommendations

Independently to the type of seed used or farming system implemented, investment in fertilizers and good quality seed are crucial to improve the profitability of cotton in Uganda. In our survey, in 2007 only 6 farmers out of 150 used chemical fertilizers and only 3 of them used an organic fertilizer. The introduction of genetically modified technologies could control bollworm or help to reduce the labor used in weeding, but the yield potential of the plant would not be achieved with the current level of fertilizer application.

Estimated values of cotton profitability do not seem to justify the investment in a complex technology. The question then is how transferable is GM technology and how easily can it be adopted by Ugandan farmers. The vertical integration of the chain could facilitate the dissemination of the technology, but availability of seed and inputs of good quality and appropriate extension support have to be guaranteed.

In the case of IR cotton it is important to point out that farmers are not using significant levels of pesticides[9] and therefore the expected reduction is pesticide used would be insignificant. If yield losses dues to Bollworm are lower than reported by farmers then the profitability of this technology will dramatically decrease. In the case of HT cotton, a potential constraint to the adoption of this technology is the very limited use of herbicides.

Furthermore, the adoption of GM cotton in Uganda would most likely impact the performance of the cotton market chain. It is very important to explore how the cotton market chain would be affected with the adoption of GM cotton and what are the institutional constraints that might limit the successful introduction of this technology. The growing importance of organic cotton production would have to be considered in any decision with respect to GM cotton adoption. One question that needs to be urgently answer is if there are possibilities for co-existence of the conventional system using GM seed and the organic system. Also, Organic cotton production needs more detailed evaluation. Price premium, for instance, makes organic production profitable but more research is needed to evaluate how this price is received by farmers.

[9] A production functions with a damage abatement specification and estimated with a non-linear regression shows that chemical pesticides are not significantly abating damage caused either bollworm, but they do control yield losses caused by other insect pest and by weeds.

While it is possible to compare the profitability of given year of organic cotton production with the conventional cotton production using GM seed this is just a very partial view. Since the interest of our research is to contribute to poverty alleviation, it is much more significant but at the same time challenging to evaluate the long term contribution of either system to the farmers' welfare. This is a research topic that needs more attention in the future.

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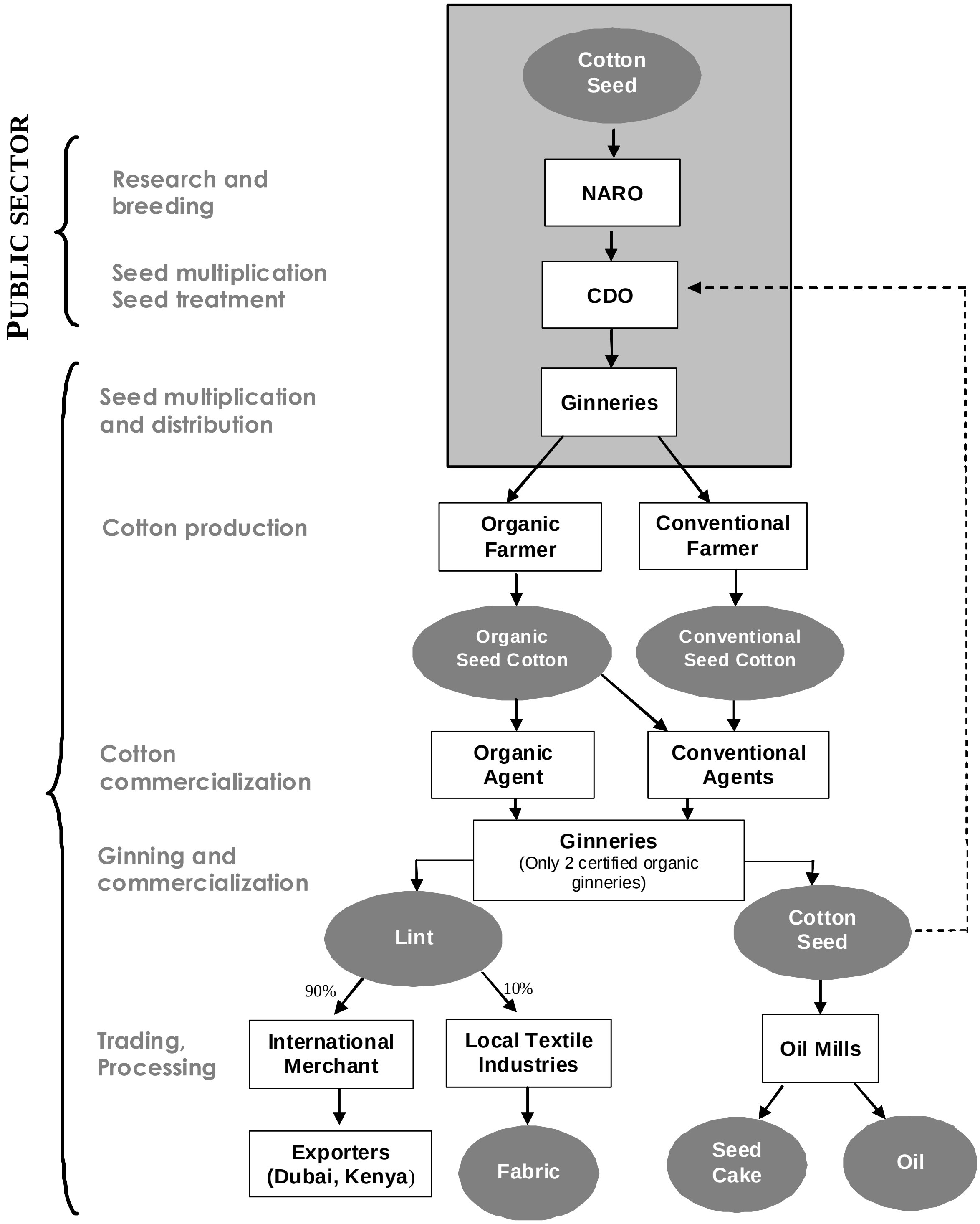
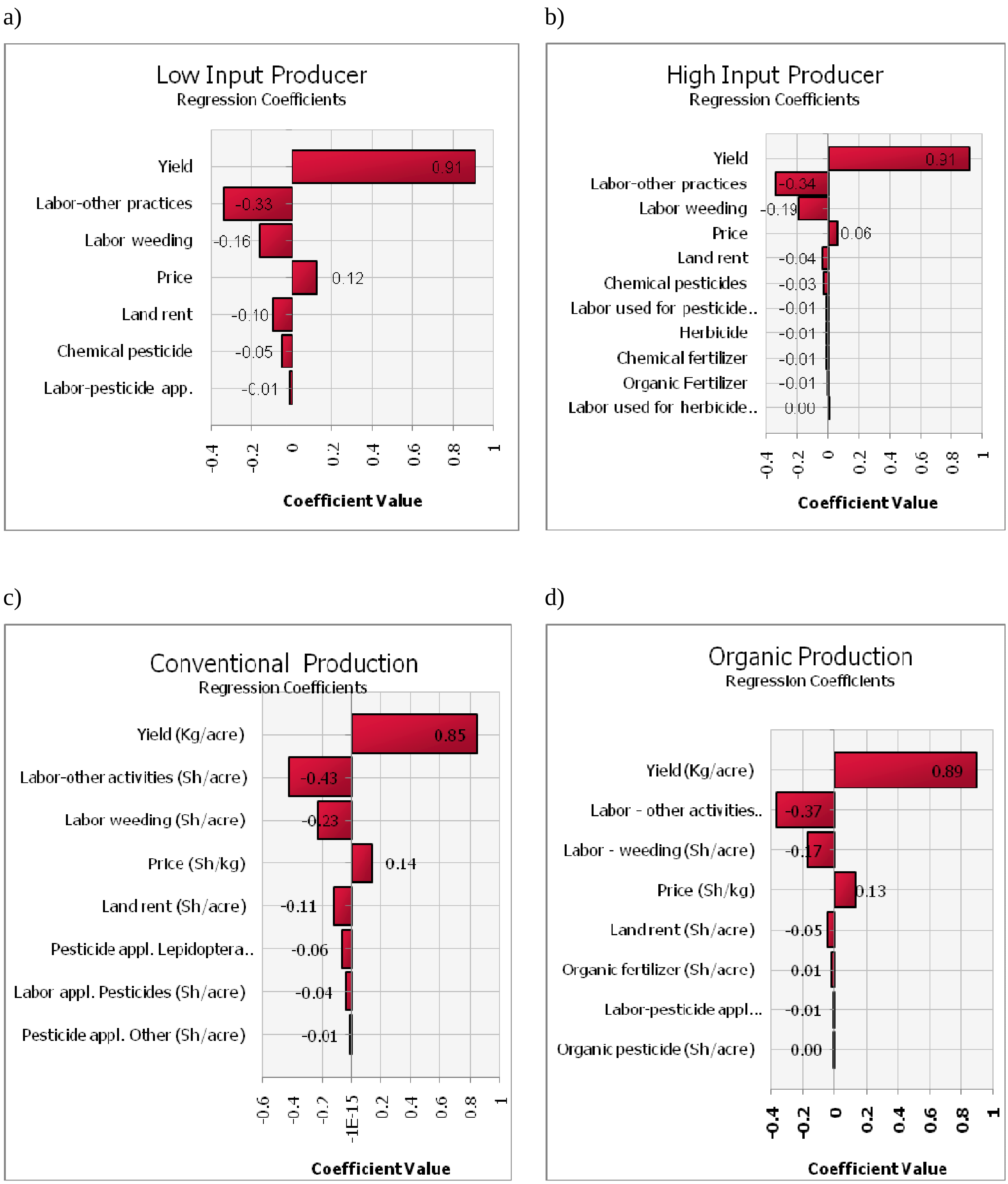
Figure 1: Cotton value chain in Uganda



Source: Own elaboration

Figure 2. Factors affecting marginal benefits of cotton producers



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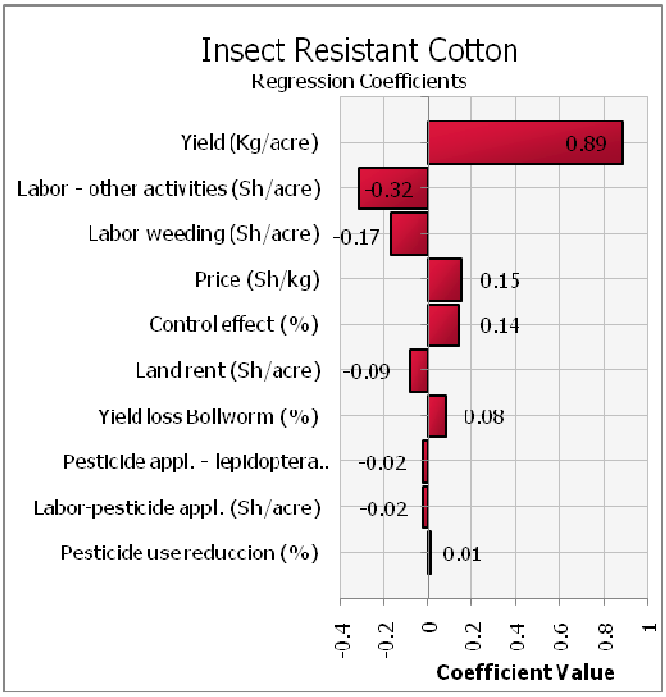
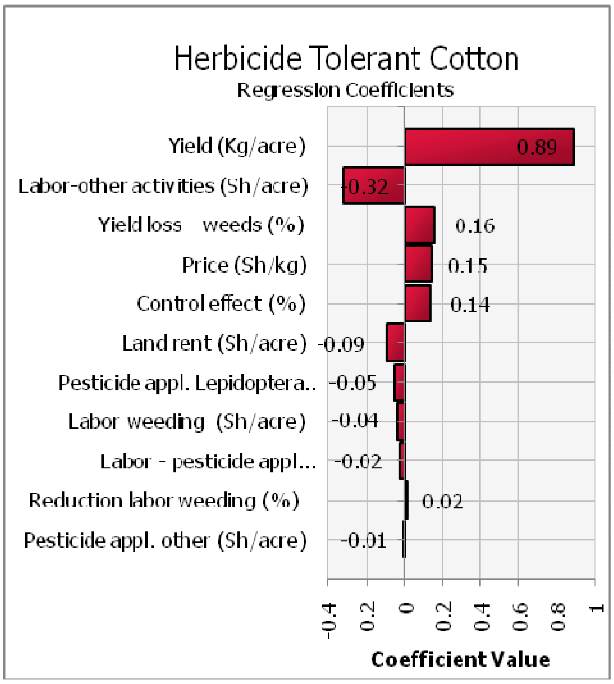


Insect Resistant Cotton
Regression Coefficients
Yield (Kg/acre)
Labor - other activities (Sh/acre)
Labor weeding (Sh/acre)
Price (Sh/kg)
Control effect (%)
Land rent (Sh/acre)
Yield loss Bollworm (%)
Pesticide appl. - lepidoptera..
Labor-pesticide appl. (Sh/acre)
Pesticide use reduccion (%)
0.89
-0.32
-0.17
0.15
0.14
-0.09
0.08
-0.02
-0.02
0.01
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Coefficient Value

f)



Herbicide Tolerant Cotton
Regression Coefficients
Yield (Kg/acre)
Labor-other activities (Sh/acre)
Yield loss weeds (%)
Price (Sh/kg)
Control effect (%)
Land rent (Sh/acre)
Pesticide appl. Lepidoptera..
Labor weeding (Sh/acre)
Labor - pesticide appl...
Reduction labor weeding (%)
Pesticide appl. other (Sh/acre)
0.89
-0.32
0.16
0.15
0.14
-0.09
-0.05
-0.04
-0.02
0.02
-0.01
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
Coefficient Value

Table 1. Assumptions and distribution used for partial budget and simulations

Components	Assumptions
Yield (Kg/acre)	The yield values were estimated: 1) Best fit distribution adjusted to minimum, mode and maximum yield elicited from each farmer. 2) Average of maximum, mode and minimum values.
Yield losses (%)	Best fit distribution based values elicited from farmers
Technology efficiency (%)	Triangular distribution for both IR cotton and HT cotton (low = 0, mean = 50, and high = 100) based on literature (Traxler and Godoy-Avila 2004; Pray et al. 2002).
Produce price (Sh./kg)	Best fit distribution based on information collected from farmers
Seed costs (Sh/acre)	Seed is distributed free of charge. The value assumed was Sh. 350 / kg. In average farmers can use 4 kg/acre for planning cotton.
Premium Price (%)	For organic producers, percentage over official price. Triangular distribution (low = 0%, mean = 12.5%, and high = 25%)
Technology fee (%)	Triangular distribution of percentage over assumed price of formal seed (low = 0%, mode = 50%, and high = 100%)
Pesticide use (Sh/acre)	Best fit distribution based on information collected from farmers.
Reduction in pesticide used to control Lepidoptera (%)	Triangular distribution (low=0%, mode= 50%, and high=100%)
Herbicide use (Sh/acre)	Best fit distribution based on information collected from farmers
Increase in herbicide use (%)	Increase over the average among current herbicide users. Triangular distribution (low=0%, mode= 50%, and high=100%)
Labor for pesticide application (Sh/acre)	Best fit distribution based on information collected from farmers
Reduction rate in labor used for pesticide application (%)	Triangular distribution (low=0%, mode= 25%, and high=50%) The reduction in labor is related to the reduction in total pesticide applied.
Labor for herbicide application (Sh/acre)	Best fit distribution based on information collected from farmers
Increase rate in labor used for herbicide application (%)	Triangular distribution (low=0%, mode= 25%, and high=50%) This value reflects an increase over the average among current herbicide users of labor used to apply herbicides

Table 2. Descriptive statistics

Variables	Total sample (N=151)		Lira (N=35)		Kasese (N=116)		F	Sig
	Mean	Std. Error	Statistic	Std. Error	Statistic	Std. Error		
Gender of the HH head (female=1)	0.09	0.02	0.03	0.03	0.11	0.03		
Control of plot (female=1)*	0.46	0.08	0.29	0.13	0.51	0.09		
Age of the HH head	44.04	1.14	42.63	2.85	44.47	1.22		
Education level of HH head (years)	2.90	0.15	3.03	0.30	2.86	0.18		
Household size (number)	7.75	0.31	7.40	0.52	7.86	0.38		
No. of males above 16	1.86	0.11	2.23	0.22	1.75	0.12		
No. of females above 16	1.74	0.10	1.71	0.17	1.75	0.12		
No. of people below 16	4.15	0.23	3.46	0.33	4.36	0.28		
Land value (USh/acre)	1,968,278	312,933	1,925,714	455,970	1,981,121	384,340		
Total area (acres)	3.51	0.49	3.30	1.05	3.57	0.55		
Cotton area (acres)	1.68	0.11	1.09	0.10	1.86	0.14	9.08	***
Experience with cotton (years)	14.68	1.04	16.86	2.36	14.02	1.15		
Probability of bollworm attacks	0.74	0.03	0.59	0.06	0.78	0.03	8.37	***
Seed cotton price (USh./kg)	651.76	6.30	660.34	14.13	649.24	7.03		
Output value (USh/acre)	421,242	43,810	193,104	28,614	490,077	54,845	8.60	***
Seed cotton yield (Kg/acre)	386.16	23.72	273.59	37.56	420.12	28.04	7.07	***
Labor used for weeding (USh/acre)	46,385	3,855	44,633	9,727	46,914	4,097		
Total labor used (USh/acre)	97,894	6,973	107,330	20,747	95,129	6,705		

Table 3. Cotton profitability for low and high input systems, season 2007/08

Cost components	Units	Low Input (N=124)	Share (%)	High Input (N=27)	Share (%)
Seed cotton - Yield	Kg/acre	361.7		458.4	
Yield loss bollworm	%	72%		78%	
Total income	**Sh/acre**	**231,638**		**322,369**	
Land rent	Sh/acre	52,333	26%	47,857	16%
Chemical fertilizer	Sh/acre			16,998	6%
Organic fertilizer	Sh/acre			14,614	5%
Herbicide use	Sh/acre			11,877	4%
Chemical pesticide	Sh/acre	17,300	9%	14,963	5%
Labor to apply pesticides	Sh/acre	4,001	2%	5,088	2%
Labor to apply herbicides	Sh/acre			4,500	1%
Labor for weeding	Sh/acre	42,066	21%	66,221	22%
Labor for other activities	Sh/acre	87,676	43%	120,718	40%
Total costs	**Sh/acre**	**203,376**		**302,836**	
Margin	**Sh/acre**	**28,262**		**19,533**	
Downside risk	**%**	**49**		**47**	
B/C		**1.13**		**1.06**	

Table 4. Cotton profitability for organic cotton producers, 2007/08 season

Cost components	Units	Conventional (N=139)	Share (%)	Organic (N=12)	Share (%)
Yield	Kg/acre	389.3		349.4	
Yield loss bollworm	*%*	*76%*		*55%*	
Yield loss weeds	*%*	*79%*			
Price reported by farmers	Sh/Kg	652		650	
Total income	**Sh/acre**	**253,802**		**227,129**	
Land rent	Sh/acre	51,894	18.9%	50,000	22.8%
Chemical fertilizer	Sh/acre	16,998	6.2%	0	0.0%
Organic fertilizer	Sh/acre	14,000	5.1%	15,229	7.0%
Herbicide use	Sh/acre	11,877	4.3%	0	0.0%
Pesticide to control Lepidoptera	Sh/acre	16,341	5.9%		
Pesticide to control other	Sh/acre	12,066	4.4%		
Organic pesticide	Sh/acre			3,339	1.5%
Labor to apply pesticides	Sh/acre	7,901	2.9%	2,084	1.0%
Labor to apply herbicides	Sh/acre	2,403	0.9%	0	0.0%
Labor for weeding	Sh/acre	49,097	17.8%	42,353	19.3%
Labor for other activities	Sh/acre	92,519	33.6%	105,922	48.4%
Total costs	**Sh/acre**	**275,095**		**218,927**	
Margin	**Sh/acre**	**-21,293**		**8,202**	
Downside risk	**%**	**43**		**58**	
B/C		**0.92**		**1.04**	

Table 5. Partial Budget Simulations

Cost components	Units	IR cotton	HT cotton	Org. + Prem. price	Organic + Bt
Yield	Kg/acre	536.37	543.33	349.4	445.70
Yield loss bollworm	***%***	***76%***		***55%***	***55%***
Yield loss weeds	***%***		***79%***		
Technology efficiency	***%***	***50%***	***50%***		***50%***
Price reported by farmers	Sh/Kg	652	652	731	731
Premium price				*12.5%*	
Total income	**Sh/acre**	**349,656**	**354,195**	**255,520**	**325,915**
Seed Cost (4Kg/acre)	Sh/acre	2,450	2,450	0	2,100
technology fee	***%***	***75%***	***75%***		***50%***
Land rent	Sh/acre	51,894	51,894	50,000	50,000
Chemical fertilizer	Sh/acre	16,998	16,998	0	0
Organic fertilizer	Sh/acre	14,000	14,000	15,229	15,229
Herbicide use	Sh/acre	11,877	17,815	0	0
increase rate of herbicide use	***%***		***50%***		
Pesticide to control Lepidoptera	Sh/acre	8,171	16,341		
reduction rate in pesticide use	***%***	***50%***			
Pesticide to control other	Sh/acre	12,066	12,066		
Chemical pesticide	Sh/acre			0	0
Organic pesticide	Sh/acre			3,339	3,339
Labor to apply pesticides	Sh/acre	5,926	7,901	2,084	1,563
reduction rate in labor costs	***%***	***25%***			***25%***
Labor to apply herbicides	Sh/acre	2,403	3,604	0	0
increase rate in labor costs	***%***		***50%***		
Labor for weeding	Sh/acre	49,097	24,548	42,353	42,353
reduction rate in labor costs	***%***		***50%***		
Labor for other activities	Sh/acre	92,519	92,519	105,922	105,922
Total costs	**Sh/acre**	**267,400**	**260,137**	**218,927**	**220,506**
Margin	**Sh/acre**	**82,257**	**94,059**	**36,593**	**105,409**
Downside risk	%	**30.7**	**25.5**	**54**	**46.4**
B/C		**1.24**	**1.27**	**1.14**	**0.32**