Farmers attitudes towards GMO crops: comparison of attitudes towards first and second generation crops in Burkina Faso

J. Tur Cardona[1]; S. Speelman[2]; E. Sanou[2]

1: Ghent university, , Belgium, 2: Ghent University, , Belgium

Corresponding author email: stijn.speelman@ugent.be

Abstract:

Genetically modified crops are the topic of a controversial debate. While some believe they have the potential to address many of the world's most challenging, interrelated problems, others mainly point to the risks, uncertainty and to some socio-economic issues. In this perspective a lot of research has been done on the agronomic and economic performance, on the effects on human health and the environmental risks and on stakeholders attitudes. Given that farmers, as actual potential producers of these crops play a crucial role in their eventual success surprisingly little attention has gone to their preferences. This paper focuses on farmers in Burkina Faso and uses two choice experiments to evaluate the preferences for two types of GM innovations: Bt cotton, which is a first generation GM crop, in which the focus is on input traits and biofortified sorghum, a second generation GM crop with a focus on output traits. Results show that farmers have a clear interest in pest resistance, and are quite satisfied with the current configuration of the Bt cotton crop. Moreover farmers are very open to the addition of micronutrients to the sorghum. This is an important finding in the context of the African Biofortified Sorghum initiative

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Abstract

Already for many years genetically modified (GM) crops are the topic of a controversial debate. While some believe they have the potential to address many of the world's most challenging, interrelated problems, other mainly point to the risks, uncertainty and to some socio-economic issues. In this perspective a lot of research has been done on the agronomic and economic performance, on the effects on human health and the environmental risks and on stakeholders attitudes. Given that farmers, as actual potential producers of these crops play a crucial role in their eventual success surprisingly little attention has gone to their preferences. This paper focuses on farmers in Burkina Faso and uses two choice experiments to evaluate the preferences for two types of GM innovations: Bt cotton, which is a first generation GM crop, in which the focus is on input traits and thus production benefits and biofortified sorghum, a second generation GM crop with a focus on output traits. Results show that farmers have a clear interest in the characteristic of pest resistance, and are overall quite satisfied with the current configuration of the Bt cotton crop. Moreover farmers are very open to the addition of micronutrients to the sorghum. Given that it concerns a subsistence crop they seem to reason mainly as consumers, appreciating the health benefits. This is an important finding in the context of the African Biofortified Sorghum initiative.

1 Introduction

Genetically modified (GM) crops are the topic of a controversial debate ever since their introduction in 1996 (Areal et al. 2011). The opposing views in the debate are fueled by the comprising complexity of the technology, uncertainty about long-term effects and several socioeconomic issues (Rey-Garcia, 2006). Their continued attractiveness lies in their believed potential to help to address many of the world's most challenging, interrelated problems, including hunger, malnutrition, disease, and poverty (Farre et al., 2010; Ezezika et al., 2012). Proponents believe that agricultural biotechnology has the potential to help African smallholders and also confer benefits to consumers, the environment and health of farmers and farm workers (Eicher et al., 2006, Ezezika et al., 2012).

While in the first place a lot of research has been done on the agronomic and economic performance and on human health and the environmental risks associated with production (Areal et al. 2011), also stakeholders 'attitudes on GM crops have received a lot of attention (eg. Kikulwe et al, 2011; Frewer et.al 2013). The second type of research however has mainly focused on consumer's preferences, overlooking other stakeholders' attitudes, particularly farmers (Bett et al., 2010).

In this perspective it has been noted by Carro and Astier (2014) that while smallholder producers are the collective most likely to be affected by the introduction of GM crops globally, they are least included in public debates and consultation about the development, implementation or regulation of this agricultural biotechnology. Nevertheless , information on the opinion of rural farmers can be instrumental in shaping more evidence-based frontier in the debate on the importance of GM crops for Africa, because they are the potential producers of GM crops. Adoption among smallholders will determine the success of agricultural biotechnology in potentially improving food security (Oparinda et al 2017). This paper therefore follows the approach of Bruestedt et al., (2008); Birol et al., (2009) , Useche et al, (2009) and Emeades et al. (2006) using a choice experiment to look at preferences of farmers in Burkina Faso for biotechnology crop traits. New in this study is that we consider both first and second generation agricultural biotechnology crops. The first generation or wave of new agricultural biotechnology contained input traits such as herbicide and pest tolerance, offering advantages to farmers in the production phase without changing the final product. The second generation of genetic modifications focuses on output traits such as improved nutritional features and processing characteristics. In Burkina Faso, Bt Cotton, a first generation crop has been commercially cultivated between 2009-2016[1], while African Biofortified Sorghum, a second generation crop is in the field trial stage. Moreover the same farmers often cultivate both cotton and sorghum. This allowed us to assess and compare the attitude of farmers towards these two types of biotechnology innovations, where the Bt cotton is well known and the biofortified sorghum a crop yet to be introduced.

2 Background : the two cases

2.1 Cotton

Cotton is one of the most important cash crops in West Africa and is a vital catalyst to economic development in the region (Vitale et al., 2007). Around the year 2000, the government of Burkina Faso became interested in Genetically Modified (GM) cotton. At that time, the cotton sector was facing considerable problems with pest damage (Fitt, 2000), leading to a deteriorating socio-economic situation in the cotton sector (Renaudin et *al* 2012). In collaboration with Monsanto, the national agricultural research institute INERA began a 5-year program of field testing of Bollgard II®, a second generation of *Bacillus thuringiensis* (Bt) improved cotton leading to insect resistance (Vitale et al., 2007). Two regional Bollgard II® varieties were developed in 2008 and the Burkina National Biosafety Agency authorized these two Bt varieties for seed production and commercialization by the national cotton companies. This meant the third commercial release of a GM crop in Africa (Vitale et al., 2007; 2010; 2014). The introduction of Bt cotton in Burkina Faso is often described as a success. For example, Vitale et al.(2007; 2010; 2011; 2014) in a series of follow-up studies, report the rapid spread (covering 70% of the cotton area), yield performance (15-20% increase), improved economic returns for smallholder farmers and the health and environmental benefits due to reduced pesticide use. Other authors, such as Renaudin et al. (2012) and Dowd-Uribe (2014), are more critical and state that the social and

[1] In 2016 the government of Burkina Faso took the decision to suspend the cultivation of Bt cotton after a dispute between the cotton sector and Monsanto on the cotton fiber length.

agro-ecological context of adoption was not given sufficient consideration. In Burkina Faso a traditional vertical integration of the cotton sector exists between farmers and companies, in which the cotton industries provide inputs, such as seeds, pesticides, fertilizers, and technical advice. Although a specific organization was established in order to give farmers a voice in decision making (the National Union of Cotton Producers (UNPCB)) the introduction of Bt cotton was a top down decision. Although most studies point out that farmers are overall satisfied with the variety (Sanou et al., 2018) , there is some concern about the affordability for poorer farmers. In this perspective it is interesting to evaluate which traits farmers value for cotton.

2.2 Sorghum

Sorghum is the most important staple crop in Burkina Faso, cultivated by most farmers. However the local sorghum cultivar is deficient in essential nutrients (da Silva et al., 2011; Traore and Stroosnijder, 2005). Given that micronutrient malnutrition (MNM) is an important challenge in Burkina Faso, which is according to UNICEF data affecting every 1 in 4 children in the country, an initiative was taken to improve the nutritive content of the local sorghum cultivar through biotechnology. This was initiated by African Harvest International (AHI) in 2001. The project was funded under the Grand Challenges in Global Health initiative by the Bill and Melinda Gates Foundation. The resulting African Biofortified Sorghum (ABS) would contain increased levels of vitamin A, Iron, and Zinc. While the addition of extra micronutrients to the local cultivar can make the sorghum crop more attractive, other characteristics like time to maturity, yield, source and cost of the seeds could also influence the farmers' adoption, and by extension determine the potential of the proposed crop. In Burkina Faso, studies have shown that farmers prefer their local sorghum cultivar over conventionally improved (hybrid) varieties that are provided by collaboration of the National Agricultural Research System and International Crops Research Institute for Semi-Arid Tropics (Olembo et al., 2010; vom Brocke et al., 2010; Adesina and Baidu-Forson, 1995).

Major causes for this are issues related to the perceived superiority of the local cultivars, penchant to seed saving culture, and transaction costs leading to inadequate demand and supply. In light of this experience it is relevant to investigate farmers preferences towards sorghum traits.

3 Method

Choice Experiments (CE) have been widely used in the agricultural and environmental economics literature and their use in development economics and cross-disciplinary research is rising (Ortega et al., 2016). More recently, several studies have used CE to evaluate farmers' behavior and preferences (Gelaw et al. 2016; Ortega et al., 2016; Schreiner and Latacz-Lohmann, 2015). Choice models have their theoretical origin in Lancasters' model of consumer choice (Lancaster, 1966), and in the Random Utility theory (Louviere et al., 2008). Lancaster stated that satisfaction will be obtained from the attributes of a product rather from the product itself, while Random utility theory observed people to be rational and as such when presented with two or more options, they would likely make a decision in favour of the one providing them higher utility. To elucidate the preference of an individual from a set of alternatives, a CE is often applied. As a stated preference elucidation method, a CE is attractive because it remains appropriate when a product is new and/or not yet commercially available (Louviere et al., 2000; Lindsay et al., 2009). Unlike the revealed preference method, the stated preference gives the researcher the room to include hypothetical attributes which might not be available in alternative products that are already in the market.

3.1 Attribute and level selection

The first stage of a CE is to select the relevant attributes and the possible levels of each attribute. Relevant attributes for insect resistant cotton and biofortified sorghum were identified by combining literature review with experts' opinion. For sorghum the engaged experts included researchers from the AHI consortium and stakeholders from the Ministry of Agriculture and Food Security in Burkina Faso. For cotton, representatives from the cotton sector, the UNPCB and INERA were consulted.

During the consultation, both for sorghum and cotton five attributes were selected to reflect the most important characteristics. The second step is assigning levels to the attributes. There is no agreed optimal number of levels but the levels assigned must reflect the range of situations that the respondents might expect to experience, and they should be feasible and realistic (Lindsay et al. 2009 and Hanley et al. 2001). Literature review, expert consultation, and market surveys were used in the selection. Quantitative values were used for example for seed price, yield, maturity attributes and required number of insecticide treatments. See table 1 for the attributes and the levels for sorghum and table 2 for cotton.

Table 1: Attributes and levels of attributes for Sorghum

Attributes	**Definitions**	**Levels**
Increased Micronutrients	Whether or not an additional micronutrient is present	Yes, No*
Seed price (CFA)	The amount paid for the purchase of seed per Kg	5000, 4000*, 3000
Seed development	The sector responsible for the production and marketing of seed	Private, public*, public-private partnership
Yield (Kg)	The expected yield per hectare (Kg)	650, 750*, 850, 1000
Days to Maturity (days)	Number of days taken for the crop to mature	70, 80*, 95, 110

*Represent the baseline level, $1 =592 CFA

Table 2: Attribute and levels of Attributes for cotton

Attributes		Levels of Attribute 1	2	3	4
1. Number of insecticide treatments		6T	4T	2T*	
2. Seed Price (CFA)		30.000	25.000	17.500	10.000
3. Seed development		Private	Public	Public-private partnership*	
4. Agricultural Practices		Change	No change*		
5. Yield (kg/ha)	Small (≤2ha)	675	750	900	
	Medium (<2ha-5ha≤)	900	1.000	1.200	
	Large (>5ha)	1.200	1.350	1.600	

*Represent the Status Quo level, $1 = 592 CFA, "Seed price" the Status Quo level is the current price on the market: 27.000 CFA, Current yield produced by the farmer represents its Status Quo level.

For sorghum the first attribute "increased micronutrients" refers to the addition of micronutrients to the local variety which can contribute to the reduction of MNM. This attribute is the core of the biofortified sorghum programme, Two levels were suggested: Yes, indicating the presence or No indicating the absence of extra micronutrients. As the transgenic biofortified sorghum has not yet been commercialized, the exact type and amount of increase in nutrients in the crop is not yet known, making the current qualitative levels the preferred option. More so, although Vitamin A is the target nutrient, the AHI experts consulted hinted that other micronutrients are being considered.

For cotton the first attribute is the required number of insecticide treatments. The required number of treatments for growing conventional cotton varieties is six . An eventual adoption of the existing GM variety allows farmers to spray only twice. A third level of four insecticide treatments was defined to see whether there are tradeoff with other characteristics.

For both crops a seed price attribute was included. For sorghum the "seed price" attribute is the price of sorghum seed per kg. It is a monetary variable that is relevant in the estimation of the utility derived from the attributes of the product. Three levels were proposed. The first level 4000 CFA is the current average price of one kg of sorghum seed in the country. The other levels 5000 CFA and 3000 CFA are an estimate on the variation of seed cost from the market survey. The rational is that the accepted seed price might be higher because of the extra features or it might be lower because farmers are not used to buying seeds in the market. For cotton the existing GM variety grown in Burkina Faso costs 27.000 CFA per sac and per hectare.. However, the seed price has been pointed by a number of studies as the main constraint impacting the economic benefit. To appraise which price will be acceptable for farmers, three lower price levels 25.000; 17.500; 10.000 CFA and one higher price of 30.000 CFA were used.

For both crops also a seed development attribute and a yield attribute is included. The "Seed development" attribute describes the sector that developed and provides the seed to the farmers. This attribute is added from the backdrop of the information trailing the GM debate that farmers in SSA might be less willing to adopt transgenic crop seed from private organizations (Mabaya, et al., 2015). It is also a general concern that due the dominance of the private sector in agricultural biotechnology research and commercialisation the benefits may not reach the poor in developing countries (Pray and Naseem, 2007). Three levels: private, public and public-private partnership were included. In the existing Bt Cotton production, the contract agreement entered by the farmers to acquire the seed empowers them to pay up through their harvest. In the ABS project, the channel of distributing, contract agreement and means of payment is yet to be determined. However, from expert consultation, it was found that for high seed viability, seed reuse might be discouraged and the best distribution channel that would make seed easily accessible to farmers will be considered.

The "Yield" attribute is the anticipated yield of the product per hectare. For sorghum the baseline yield 750kg/ha was obtained through the consultation with experts in the Ministry of Agriculture and Food security. The study of Lacy et al. (2006) on farmer choice of sorghum varieties in southern Mali gave an insight on the other levels. The yield attribute is important to evaluate the findings of previous research by Adesina and Baidu-Forson (1995) who opined that the yield attribute of sorghum is “barely significant” in farmers adoption of modern sorghum varieties. To get a reliable range of yields for cotton we first looked at ten years of yield data from the Sofitex database. This investigation covered the last 5 years before and the first 5 year after the commercial release of Bollgard II. Finally three levels of yield value were adjusted based on the type of farmers (Large, Medium and Small).

The final attribute for sorghum is “Days to Maturity”. It refers to the number of days taken for the crop to mature. This attribute is added due to the desire in the region for drought resistant crops. A crop with a shorter maturity period means a higher ability to resist the climatic variations, and it is often preferred. Again, the study of Lacy et al., (2006) was vital in the identification of levels. Four levels were specified with 80 days being the average of sorghum maturity date in the study area. The final attribute for cotton is a change in agricultural practices. This attribute was added because to capture the concern that more changes than the number of sprayings are necessary to cultivate Bt cotton.

3.2 Design of the Experiment

The second stage in the DCE is designing the choice sets. A choice set is a group of hypothetical alternatives constructed through experimental design. A fractional factorial design was used for the two choice experiments in this study. The fractional factorial design generates a sample of the full design in such that the most important effects can be estimated (Lindsay et al., 2009 and Alpizar et al., 2001). An advantage of fractional factorial design is that the reduction in the number of choice sets does not lead to a concomitant loss in estimation power (Hanley et al., 2001). The D – efficiency approach was used to design the experiment with the help of SAS software (Kuhfeld et al., 1994). A D-efficient design tends to greatly reduce the predicted standard errors of the parameter estimate and produce even stronger statistical results (Hoyos, 2010; Rose et al., 2008). The alternatives were not labelled because then there is a risk that respondents ignore the attribute and concentrate on the product alternatives (Saldias et al., 2016). This is particularly a problem in sensitive market research like GM crops, where a strong attitude can exist due to controversies and external influences.

In both choice experiments, two opt-out alternatives were included. One describing the desire to continue with current sorghum or cotton seed, and the other covering the intention to abandon sorghum or cotton production. The respondents were also asked during the interview about their current yield and behavior (eg their frequency of purchase of seeds, their pesticide application frequency), in a way that their current values for the status quo could be used in the analysis.

The sorghum CE contained 12 choice cards each with six alternatives. In the Cotton CE this was 24 choice cards with five alternatives. To avoid that the survey would become too long, the design was blocked using SAS into three parts for the cotton CE and in two parts for the sorghum CE. Blocking helps to promote response efficiency by reducing cognitive effort for each respondent (Johnson et al., 2013). Respondents were randomly assigned to one of the blocks, facing 6 choice sets or situations for the sorghum case and 8 randomly chosen choice sets for cotton. In this way a total of 5400 individual choices were obtained for the sorghum study (6 alternatives x 6 choice sets x 150 farmers) and a total of 12.960 individual choices were obtained for the cotton study (5 profiles x 8 choice cards x 324 farmers).

3.3 Econometrical Model

Following the econometric model specification proposed by Greene and Hensher (2003), a Conditional Logit (CL) was specified. The CL presents a holistic preference of the whole sample. The general econometric model consists of parameterized utility functions U_{nij} in terms of observable independent variables $\beta_s X_{nij}$ and unknown parameters or Error components ε_{nij} as shown below.

$$U_{nij} = \beta_s X_{nij} + \varepsilon_{nij} \qquad (1)$$

Simply put, U_{nij} is the utility that a farmer n, derives from the selection of alternative i in the choice set j. The β is the parameter vector which encompasses first, the choice parameter and second, socioeconomic and motivational parameter vectors, while X is the vector of attributes, and ε is the error component. The inclusion of the error component implies that researchers can only predict with some level of uncertainty the choice of the respondent; therefore, it is assumed that choices made among the alternatives will be a function of the probability that the satisfaction associated with the selected option is higher than that of the alternatives not selected. Nevertheless, for this probability function to be accurate, the error term must be identical, independently distributed and follow a Type 1 or Gumbel distribution (Rungie et al., 2011). If this is the case, the conditional probability that the farmer n, selects the alternative i in the choice set j is given as

$$P_{nit} = \frac{\exp(\beta_s X_{nij})}{\sum_{i=1}^{I} \exp(\beta_s X_{nij})} \qquad (2)$$

By including the seed cost attribute, it is possible to calculate the farmers' valuation or willingness to pay (WTP) for other attribute changes. This is done by dividing the non-price attribute with the price attribute, as specified below

$$WTP = \frac{\beta_k}{(-)\beta_c} \qquad (5)$$

where β_k is the coefficient of a non-seed price attribute, and β_c is the coefficient of the seed price attribute. In determining the farmers' valuation or welfare measure, attributes presented in quantitative form are often compared with other quantitative attribute. This is also similar with qualitative attributes.

3.4 Data

The study was conducted in 2015-2016 in Burkina Faso with respondents from three districts; Dedougou, Bobo, and Diebougou. The districts were purposely selected because they are among the main cotton and sorghum growing areas in Burkina Faso. Being located in the cotton zone, most of the farmers cultivate cotton but they also allocate some percentage of their land to sorghum production (Sanders, 2016). The respondents used for the study were drawn from a list of farmers belonging to a local cotton cooperative (SOFITEX). For the study on cotton a total of 324 farmers were selected. A stratified sampling method was adopted in the selection of farmers to interview. This stratification relied on the three key features (type of cotton variety currently grown, type of farmer, position occupied in GPC). In each stratum farmers were randomly selected. A stratified subsample of 150 farmers of the above sample was used for the sorghum study. The sample contained 50 farm households from each of the 3 districts. This data collection took place a couple of months after the first one.

In both cases data was collected from the household head using a structured questionnaire by a trained survey team. The survey was conducted face to face. The individual assessment was adopted due to the sensitivity of the subject matter. The farmers were trained briefly on how to respond to questions, and were assured of the confidentiality of their response. The surveys usually took 30 minutes, covering 3 parts, 1. information regarding their socioeconomic and farm characteristics, 2. A set of motivational questions to ascertain their nutritional knowledge and attitude towards GM crops, and 3. the application of the choice experiment.

4 Results and discussion

4.1 General characteristics of the two samples

Table 3 and 4 give an overview of some general characteristics of the sampled farmers. In terms of characteristics of the household head the subsample of sorghum farmers is very similar to the larger cotton sample. It mainly concerns middle aged, low educated farmers. The samples differ in farm size, with generally larger farm sizes for those farmers who cultivate both cotton and sorghum. It can also be seen that most farmers already grow cotton for quite some time. Sorghum is mainly grown as a subsistence crop and farmers usually use their own seeds from the past season..

Table 3: Socio-economic and farm characteristics in cotton sample (n = 324)

Parameters	**Total Sample (324)**	
	Mean	S. D.
Socioeconomic characteristics		
Age (average years)	41.9	8.1
Education level (% literacy)	31.8%	
Cotton acreage (hectare)	3.94	3.22
Total acreage (hectare)	4.35	3.22
Total annual cotton Yield yield (Kg/ha)	1034.25	238.76
Experience with cotton	19.9	3.94
Farm Characteristics Bt growers		
Experience with Bt cotton	5.38	1.5
Yield	1115.3	241.86

Table 4: Socio-economic and Farm Characteristics of farmers in sorghum subsample (n= 150)

Parameters	**Total Sample (150)**	
	Mean	S.D.
Socioeconomic characteristics		
Gender (% of males)	93.3	
Age (average years)	44.6	9.4
Education level (% literacy)	32	
Sorghum acreage (hectare)	1.59	0.87
Total acreage (hectare)	8.25	8.24
Total annual sorghum yield (Kg/ha)	790	138.7
Farm Characteristics (% of yes)		
Importance of sorghum		

Sorghum as household staple	72.7
Grows sorghum every season	84.7
Purpose of sorghum production	
Consumption only	91.3
Sales only	8.7
Sorghum seed provision (% of farmers)	
Save seed for next season	92.7
Sometimes purchase seed from market	6.7
Seed source does not matter	59.3

4.2 Outputs of the choice experiments[2]

When looking at the results of the conditional logit for the cotton CE (table 5) most attributes appear to be significant determinants of the preferences of farmers. Cotton farmers prefer higher yields, and dislike varieties requiring more insecticide treatments or being more expensive. They also prefer public-private development of seeds above a pure private development. The attribute related to the agricultural practices and that for public seed development were not significant. It is also interesting to see that 51% of the farmers prefers the status quo. In this light it is interesting to note that this holds most for the part of the sample cultivating Bt cotton. So this confirms earlier studies that found that farmers are quite satisfied with the advantages of Bt cotton.

Table 5: Conditional Logit representing Utility Derived from sample for cotton attributes

Utility parameter	**Coefficient**	**Standard Error**
Yield	.00462***	.00013
Private seed source[1]	-2.11340***	.09999
Public seed source[1]	.00425	.06477
Number of Spray	-.69034***	.02296
Seed Price	-.61169D-04***	.3346D-05
Agricultural practices	.00102	.03424
Probability of selection an opt out alternative		
Alt4: Preference for the status quo		51%
Alt5: Abandon of cotton growing		0%

[1]Compared to public-private partnership, ***, **, * = Significant level at 1%, 5%, 10% level

According to the results of the conditional logit model for sorghum (table 6) all attributes are significant. Again farmers, as expected, prefer higher yields and lower prices. Also the negative attitude towards pure private crop development is confirmed and even a positive attitude towards public development is found. In addition farmers positively evaluate the addition of micro-nutrients to the sorghum varieties , which is of course crucial for the ABS project. Finally the model output confirms that farmers prefer short maturing varieties.

[2] The current version of the paper does not consider heterogeneity in the preferences of the farmers, we are now developing some analyses that take this aspect into account, which allows better comparisons.

Another point which is surprising is that farmers, seem to be quite keen on changing their variety for a new one (with only 27 % opting for the Status quo).

Table 6: Conditional Logit Representing Utility Derived from Sorghum Attribute

Utility parameter	**Coefficient**	**Standard Error**
Increased Micronutrients	3.3835***	0.1685
Seed price	-0.0008***	0.0006
Public seed source[1]	0.7164***	0.1088
Private seed source[1]	-0.6964***	0.1419
Yield	0.0069***	0.0004
Days to maturity	-0.0333***	0.0032
Probability of selecting an opt out alternative		
Alt 5: Preference for local seed	27%	
Alt 6: Abandon (GM) sorghum	0%	

[1]Compared to public-private partnership,

***, **, * = significant at 1%, 5%, 10% level

To be able to interpret and compare the results of both choice experiments better, the WTP for attribute changes was calculated and expressed in terms of % of the status quo price in table 7 for Cotton and table 8 for Sorghum. It is interesting to see that the WTP in % of current price for extra yield is clearly lower for cotton then for sorghum. A reason for this might be that sorghum is a food crop and a subsistence crop in the farming systems in Burkina Faso.

For the change from private to PP seed development farmers are prepared to pay respectively 12% of the Bt cotton price or 21 % of the sorghum price.

While a reduction in insecticide treatments is clearly valued by the farmers, the WTP for eliminating one treatment is not that high. This could point to the fact that the current price of Bt might be set too high. For sorghum it is quite striking that farmers would be prepared to pay double the current price for the addition of the micronutrients. This is an important finding for the ABS project.

Table 7 WTP (in % of status quo price) for attribute level changes for cotton

Attribute change	WTP
Extra yield (kg/ha)	0.028%
From PP to Private seed source	-12%
Public seed source[1]	/
Extra insecticide treatment	-4%
Agricultural practices	/

Table 8 WTP (in % of status quo price) for attribute level changes for sorghum

Attribute change	WTP
Addition of micronutrients	105%
From PP to Public seed development	22%
From PP to Private seed source[1]	-21%
extra yield (kg/ha)	0.21%
Extra day to maturity	-0.10%

5. Conclusion

Already for many years genetically modified (GM) crops are the topic of a controversial debate. While some believe they have the potential to address many of the world's most challenging, interrelated problems, other mainly point to the risks, uncertainty and to some socio-economic issues. In this perspective a lot of research has been done on the agronomic and economic performance, on the effects on human health and the environmental risks and on stakeholders attitudes. Given that farmers, as actual potential producers of these crops play a crucial role in their eventual success surprisingly little attention has gone to their preferences. This paper focuses on farmers in Burkina Faso and uses two choice experiments to evaluate the preferences for two types of GM innovations: Bt cotton, which is a first generation GM crop, in which the focus is on input traits and thus production benefits and biofortified sorghum, a second generation GM crop with a focus on output traits. Results show that farmers have a clear interest in the characteristic of pest resistance, and are overall quite satisfied with the current configuration of the Bt cotton crop. Moreover farmers are very open to the addition of micronutrients to the sorghum. Given that it concerns a subsistence crop they seem to reason mainly as consumers, appreciating the health benefits. Further research should reveal whether, such clear positive attitude towards a biotechnology crop, is influenced by the mainly positive experiences with BT cotton. Another interesting finding is that for both crops farmers seem to dislike the fact that the crop is developed and commercialized purely by the private sector. They seem to agree that the role of the public sector is to induce private research and to conduct research that will benefit those neglected by the private sector (Pray and Naseem, 2007). This issue seems to be even more sensitive for a food crop like sorghum. Further research could focus on the preference heterogeneity of the sampled farmers. In addition it would be interesting to see how the experiences with a commercialized GM crop (Bt cotton in this case) contribute in shaping the preferences of farmers towards newly introduced crops.

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