Baseline Study for Impact Assessment of High Quality Insect Resistant Cowpea in West Africa

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AFRICAN AGRICULTURAL TECHNOLOGY FOUNDATION
FONDATION AFRICAINE POUR LES TECHNOLOGIES AGRICOLES

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Contents

List of Tables

List of Figures

Acronyms and abbreviations

AATF	African Agricultural Technology Foundation
ADPs	Agricultural Development Programs
BBC	British Broadcasting Corporation
Bt	*Bacillus thuringiensis*
CerPA	Centre Régional pour la Promotion Agricole
CLCAM	Caisse Locale de Crédit Agricole Mutuel
CRSP	Bean/Cowpea Collaborative Research Support Programme
DECOR	Département de Recherche en Economie Rurale
DNSI	Directio n Nationale des Statistiques et de l'Informatique
ECOFIL/IER	Economie des Filières de l'Institut d'Economie Rurale
GM	Genetically Modified
GMO	Genetically Modified Organism
IITA	International Institute of Tropical Agriculture
INERA	Institut de l'Environnement et de Recherches Agricoles
INRAN	l'Institut National de la Recherche Agronomique du Niger
IPM	Integrated Pest Management
MAEP	Ministère de l'Agriculture, de l'Elevage et de la Pêche
NGOs	Non-Governmental Organisations
OMA	Observatoire du Marché Agricole
ONASA	Office National pour l'Approvisionnement et la Sécurité Alimentaire
PCU	Projects Coordinating Unit
PRONAF	Cowpea Project for Africa
SIMA	Système d'Information des Marchés Agricoles
WCA	West and Central Africa
WTP	Willingness to pay

Summary

Cowpea is the most important grain legume and fodder crop in the dry savannas of Africa. Grown on more than 12.5 million hectares, grain yields from improved varieties are higher than local varieties, but require 2 to 3 insecticide sprays to control major pests compared to local varieties. Losses due to *Maruca* alone reach 80% and so far resistance to *Maruca* has been limited.

To address some of these challenges the African Agricultural Technology Foundation (AATF) has initiated a project which promotes farmers access to improved cowpea technologies and biotechnological products. Availability of *Bt* cowpea lines with resistance to *Maruca* will contribute significantly to: (1) increased production and incomes, (2) improved nutrition, (3) enhanced soil fertility, (4) increased storability, and (5) decreased pesticide use.

The study initiated by AATF and executed by the International Institute of Tropical Agriculture (IITA) and Purdue University aims to:

1. elicit consumer preferences, acceptability, willingness to pay and adaptability of *Bt* cowpea to local conditions in west Africa
2. assess the competitiveness and potential market niches for *Bt* cowpea
3. identify strategies for capacity building of west African seed organisations for *Bt* cowpea
4. assess the *ex-ante* economic impact of *Bt* cowpea at farm, country and region levels.

Preliminary results show that:

1. **information exchange and awareness** are important for the adoption and large diffusion of *Bt* cowpea
2. there is a **high willingness to pay** for *Bt* cowpea seed by farmers
3. given the potential of reducing health hazards by lowering the use of toxic synthetic pesticides, both **farmers and consumers are willing to pay a premium price** for *Bt* cowpea as an alternative to harmful cotton pesticides. The opportunity costs of using cotton insecticides include the economic losses encountered by the farm household when a family member is sick due to the misuse of chemical insecticides
4. urban consumers in regional markets believe that *Bt* cowpea may be safer than conventional cowpea treated with chemicals
5. *Bt* cowpea will raise incomes substantially at farm, household, community and regional levels.

Background

Cowpea *(Vigna unguiculata)* is the most important grain legume and fodder crop in the dry savannas of tropical Africa. It is grown on more than 12.5 million hectares of largely smallholder farms, with an estimated production of more than 3 million metric tonnes. Over 60% of cowpea growing area is in west and central Africa (WCA), but a significant acreage is also cultivated in east and southern Africa. Nigeria and Niger account for 5 and 3 million hectares respectively. Other countries with significant areas under cowpea farming are Burkina Faso, Cameroon, Ghana, Mali and Senegal.

Since the early 1980s, the International Institute of Tropical Agriculture (IITA), the Bean/Cowpea Collaborative Research Support Program (CRSP) and Purdue University, in collaboration with national, regional and international institutions, have developed through a conventional breeding approach high yielding grain type and dual purpose cowpea varieties combining resistance to major diseases, insect pests and *Striga.* These varieties are short cycle (60–75 days) and therefore escape drought, a major constraint in the semi-arid agro-ecological zone where most of the cowpea is grown. Potential grain yields from improved varieties are much higher (2.0–2.5t/ha) than local varieties (0.7–1t/ha) but require a minimum of 2 to 3 sprays of insecticide to control major pests, among them *Maruca vitrata* pod borer. Losses due to *Maruca* alone can reach up to 80% and so far resistance to *Maruca* has been limited.

The costs of insecticides recommended by the extension services are high and access to input markets is poor for most of the cowpea producers in west Africa leading to the use of highly toxic cotton insecticides and other dangerous chemicals to control cowpea pests. The misuse of pesticides in general has caused deaths and significant health problems in cotton and cowpea producing areas.

To address some of these challenges, the African Agricultural Technology Foundation (AATF) has initiated a cowpea project, which will promote small farmers' access to conventional technologies and modern biotechnological products and create a conducive seed policy environment to enhance the productivity of cowpea, thereby addressing the twin problem of food insecurity and poverty among smallholder farmers in Africa. Appropriate resistance when genetically incorporated into cowpea, can increase its productivity and storability. Availability of genetically improved cowpea lines with resistance to the pests that cause the greatest damage to cowpea will contribute significantly to: (1) increased production and incomes, (2) improved nutrition and health for farmers and consumers, (3) enhanced soil fertility and stability, and (4) environment protection through pesticide use.

Biotechnology may offer a cost effective and sustainable solution to cowpea pest control and in particular *Maruca vitrata* through the insertion of *Bacillus thuringiensis* (*Bt*) in cowpea varieties. Genes from the *Bt* bacteria have been inserted in several other crops

so that they produce their own toxins against similar insects (for example *Bt* maize and *Bt* cotton). *Bt* proteins active against *Maruca* are being identified at Purdue University with the support of the Bean/Cowpea Collaborative Research Support Program (CRSP). Significant progress is being made in developing a transgenic cowpea with *Bt* gene (TJ Higgins, personal communication). The new *Bt* cowpea will be resistant to the pod borer *Maruca* and will decrease the number of insecticide sprays and the overall costs of cowpea pest control. Earlier studies (Langyintuo, 2003) predicted substantial benefits to be derived from *Bt* cowpea for producers and consumers in the Sahelian regions of west Africa.

Like with any new technology, the adoption and diffusion of transgenic crops suggest that the economic, marketing and consumer preferences as well as food, feed and environmental safety aspects should be considered early in the process of developing a transgenic crop to ensure ease of delivery, acceptability and access of the product to end users. This is a sure way of safeguarding against a potential technology backlash among consumers as has been demonstrated in some parts of the world by some consumers.

Objectives of the study

General objective

This study was commissioned by AATF to assess the potential regional impact of *Bt* cowpea through an *ex-ante* analysis prior to the introduction of transgenic cowpea in west Africa.

Specific objectives

1. To assess market demand and enabling environment of *Bt* cowpea in west Africa.
2. To elicit consumer preferences, acceptability, willingness to pay and adaptability of genetically modified (GM) cowpea to local conditions in west Africa.
3. To assess the key factors affecting the potential adoption of *Bt* cowpea by farmers in main cowpea growing areas in west Africa.
4. To assess the competitiveness and potential market niches for *Bt* cowpea and related capacity building in west Africa.
5. To evaluate an *ex-ante* economic impact of *Bt* cowpea at farm, consumer and aggregate levels.

Geographical focus and data collection

The study covered the main cowpea growing agro-ecological zones in west Africa. Countries surveyed included Benin, Burkina Faso, Mali, Niger and Nigeria. Sample sites included villages covered and not covered by the Cowpea Project for Africa (PRONAF) in each agro-ecological zone per country. Villages were randomly selected where there were no PRONAF sites. In each village a sample of 15 farm households were chosen for decision making, modelling and perception surveys.

The study was carried out in two phases. The first phase focused on a review of available data and information on the key themes addressed in the specific objectives. The second phase focused on interviews with producers and consumers involved in the cowpea value chain (production, storage, marketing and demand perceptions) to assess their views on the size, structure, main constraints and opportunities of production and market, awareness, and use of *Bt* cowpea.

Main research hypotheses

The study was carried out by testing the following hypotheses.

Hypothesis 1: The willingness to pay (WTP) price for the new *Bt* cowpea seed will be at most 4,000 FCFA/kg.

Hypothesis 2: The cowpea production per farm will increase by at least 30% and at most 80% when *Bt* cowpea is adopted. *Bt* cowpea is financially and economically profitable for small farmers in west Africa.

Hypothesis 3: Assuming constraints in access to input and output markets, farm households will expect an increase of at least 15% in income and welfare through the adoption of *Bt* cowpea.

Hypothesis 4: An adverse consumer reaction will reduce expected income from *Bt* cowpea.

Hypothesis 5: Seed availability is key to the adoption and diffusion of *Bt* cowpea. Poor access to seed can decrease the expected income by 50%.

NB: The level of changes proposed in the first 3 hypotheses were based on field data of yield gain from spraying Decis (Ibro et al, 1991), a common pesticide used for cowpea pest control in west Africa. *Bt* cowpea is compared to Decis with the same yield gain. Hypothesis 4 tested the severity of the problems faced by seed sectors in the sample countries in west Africa. In relation to hypothesis 5, the supply of cowpea seed in west Africa is a key constraint. Beside poor organisation and infrastructure issues, limited profitability of seed companies marketing non-hybrid seed varieties limit seed supply (Lambert et al, 2003; DeVries and Toenniessen, 2001).

Analytical framework

Theoretical model

The theoretical framework used to analyse the data included two basic models, one for modelling the representative farm household for optimal decision making and a second one for the representative consumer perceptions and willingness to pay and consume *Bt* cowpea products. A typical representative cowpea farm household in a Sahel agro-ecological setting aims to maximise both food security (reduced risk) and income in an environment characterised by poor resource endowments, limited access to agricultural technologies, poor access to input and product markets and covariant risks like early and end of season droughts, pests and diseases attacks. Consumers maximise utility as a proxy for income and face uncertainty about product quality at the time of purchase. It is difficult for both sellers and buyers to obtain accurate information on product quality.

Empirical analysis

Consumer preferences – To assess consumer preferences without actual physical products to test, willingness to pay (WTP) surveys were carried out among representative consumers in some selected urban centres. Methodological issues in WTP are outlined by Freeman (1993), Lusk and Hudson (2004), and Bocaletti and Moro (2000). Like with producers, econometric models were used to analyse key factors affecting the WTP of *Bt* cowpea by consumers.

Surveys and elicitation were used to collect perceptions and estimate farmers' option-based WTP for *Bt* cowpea seed. Hypothetical market scenarios were explained to both farmers and consumers for selling and buying cowpea seed. 'Cheap talk', the main survey method used under hypothetical scenarios consisted of explaining market scenarios to respondents where they were asked to imagine being a customer in a market buying *Bt* cowpea seed for the next cropping season. The seller then outlined the advantages and disadvantages of both conventional and *Bt* cowpea seed prior to offering these products at given prices to the client. The seller also proposed insecticide in addition to both conventional and *Bt* cowpea seeds. The buyers were to choose option quantities for the cowpea seed they are sure to buy and plant whether the cropping season is characterised by good rainfall or not. In some cases, farmers provided option prices that are the amount of money they were sure of spending on cowpea seed regardless of the type of weather during the cropping season.

Farm level benefits – Expected farm level benefits were estimated using representative farm household models and farm level willingness to pay surveys. Econometric model,

'Logit', was used to assess key factors affecting the adoption of *Bt* cowpea by farmers in each country. Policy Analysis Model was used to assess the financial and economic profitability of *Bt* cowpea.

Supply and demand of inputs and output relative to Bt *cowpea* – A model of supply and demand was used to analyse the interaction between potential sellers and buyers of *Bt* cowpea in west Africa. Key urban and rural markets were selected for data collection on prices, interactions, buyers and sellers, and sub-sector linkages.

Data

Secondary data was collected on cowpea prices in urban and rural markets per local area in each of the five countries (Nigeria, Niger, Benin, Burkina Faso and Mali). Data on costs and benefits of farm production and cowpea cropping was also collected.

Primary data was collected from farmers, producers and resource persons through formal and informal surveys. Samples of farmers and consumers were determined based on typology (socio-economic characteristics) and a random selection by cluster. Data was collected on socio-demographic characteristics of consumers and producers, farm characteristics, farmer and consumer perceptions on GMO and *Bt* cowpea, and preferences and market prices. Table 1 presents samples of consumers and producers in each country.

Table 1. Sampling of consumers and producers in selected countries

Country	Target group of beneficiaries	Agro-ecological zones	Cities/ villages	Consumer sample size	Producer sample size
Benin	Consumers	3	12	400	NA
	Producers	3	12	NA	168
Niger	Consumers	2	4	160	NA
	Producers	2	8	NA	120
Nigeria	Consumers	3	6	240	NA
	Producers	3	12	NA	180
Burkina Faso	Consumers	2	4	160	NA
	Producers	2	8	NA	160
Mali	Consumers	2	4	160	NA
	Producers	2	8	NA	160
Total	NA	NA	NA	1120	788

Preliminary results 1: Awareness and perception of producers, and rural and urban consumers on GMO and *Bt* cowpea

Benin

Preliminary results for the producer perceptions in the Valley agro-ecological zone

Most financial transactions involving cowpea in west Africa take place in informal settings so that consumers hardly believe in what sellers say about the quality of their products at the time of purchase (Langyintuo et al, 2003).

Information and awareness of characteristics of *Bt* cowpea is important for its adoption and diffusion. The average farm household exhibits **a premium (higher than current price) for *Bt* cowpea**. The average farmer in the Oueme Valley zone **is willing to pay a higher price or higher quantity for *Bt* cowpea seed** compared to conventional seed when both products are offered at the same price. With *Bt* cowpea, the average farm household located in front of the Valley would reduce the use of cotton chemical insecticides to control pest infestation in cowpea, and **would therefore reduce potential health hazards to both cowpea growers and consumers**.

NB: Cotton chemical insecticides are quite effective at controlling pest infestation, but they involve health hazards when mishandled and handling them appropriately requires expensive equipment and training. Most cowpea growers located in front of Oueme Valley mishandle cotton chemical insecticides and are therefore subject to various health hazards. Moreover, the residues of cotton insecticides can remain on cowpea products and therefore cause health hazards to consumers.

Based on the expected impact analysis ***Bt* cowpea would provide economic benefits to cowpea growers** in the Valley agro-ecological zone.

Bt cowpea availability would lift a phytosanitary constraint for a farm household that is currently planting much less cowpea compared to the average farm in front of the Valley.

The benefits provided by *Bt* cowpea for the average farm household are likely to reflect the benefits provided by **health improvement due to a reduction in the use of harmful cotton chemical insecticides**.

These health benefits could reflect **a diminution in health costs and/or a reduction in the opportunity costs of using harmful cotton chemical insecticides**. The opportunity

costs of using cotton chemical insecticides include the economic losses encountered by the farm household when a family member is less productive due to the misuse of chemical insecticides.

Preliminary results for the perceptions of urban and rural consumers: Glazoué Market (regional market for Benin, Togo, Nigeria, Niger and Burkina Faso)

Consumers were surveyed to estimate their option-based WTP for *Bt* cowpea. Once buyers are interested in *Bt* and/or conventional cowpea grains, they are asked to provide option quantities for these products, that is quantities of cowpea they are sure to buy regardless of their monthly household income.

The average urban household in the regional market of Benin (Glazoué) **preferred *Bt* cowpea** to its conventional counterpart. Most respondents believed ***Bt* cowpea to be safer than conventional cowpea**. This is mainly due to the fact that the use of inappropriate pesticides caused deaths among consumers in Benin in the last ten years (Aitchédji et al, 2004).

The gross benefits from *Bt* cowpea for all producers and consumers (rural producers and consumers and urban consumers) is estimated at 8 billion CFA in Benin (US$ 14.5 million per year).

Nigeria

Preliminary results for the producer perceptions

In Nigeria, 90% of the sampled producers were not aware of GM food. Only 10% reported some information on GM food. But 84% of producers would buy *Bt* cowpea seed at current market prices. About 70% of producers were willing to pay a premium of 30% (US$ 0.20/kg) for *Bt* cowpea seed over conventional cowpea seed price. A small group of farmers were willing to pay more than 60% of premium price for *Bt* cowpea seed.

Preliminary results for consumer perceptions

Results show that only 16% of rural consumers are aware of GM food compared to 33% in urban areas in northern Nigeria. Rural consumers (82%) prefer *Bt* cowpea.

Three main reasons were given by rural consumers to justify their preference for *Bt* cowpea. Their opinions are that *Bt* cowpea should be:

- safe for human consumption (95% of consumers who accept *Bt* cowpea)
- easy to cook for rural households (94%)

- able to increase the income of the rural farm household and therefore increase its welfare. The rural cowpea consumer tends also to be a cowpea producer.

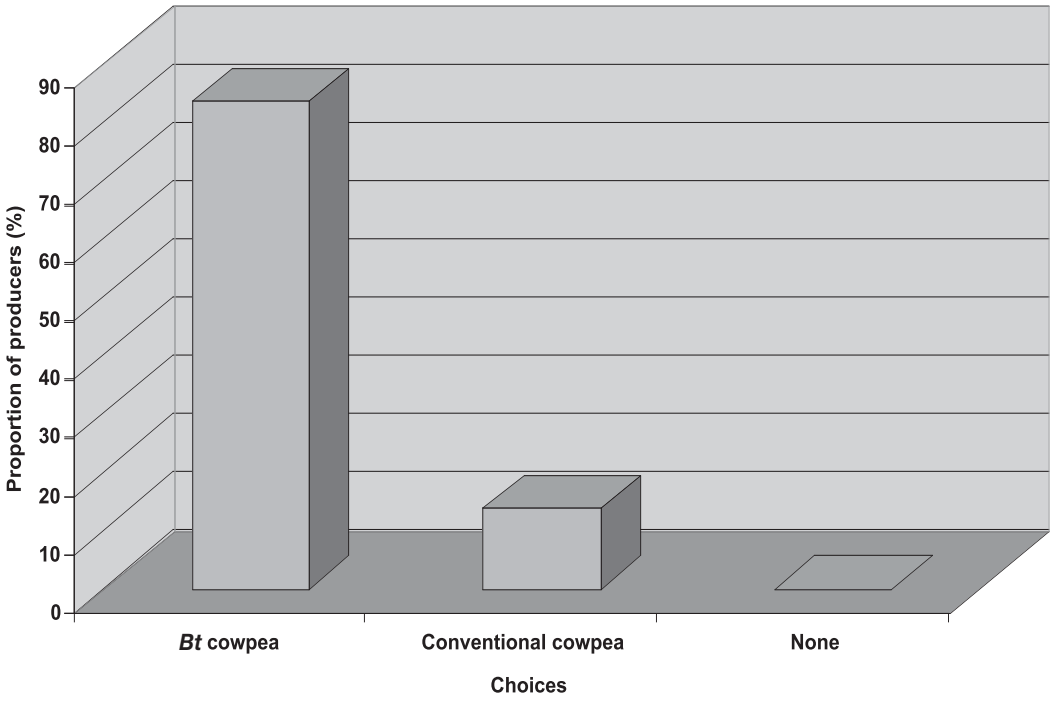

Figure 1. *Producer preferences for cowpea in Nigeria*

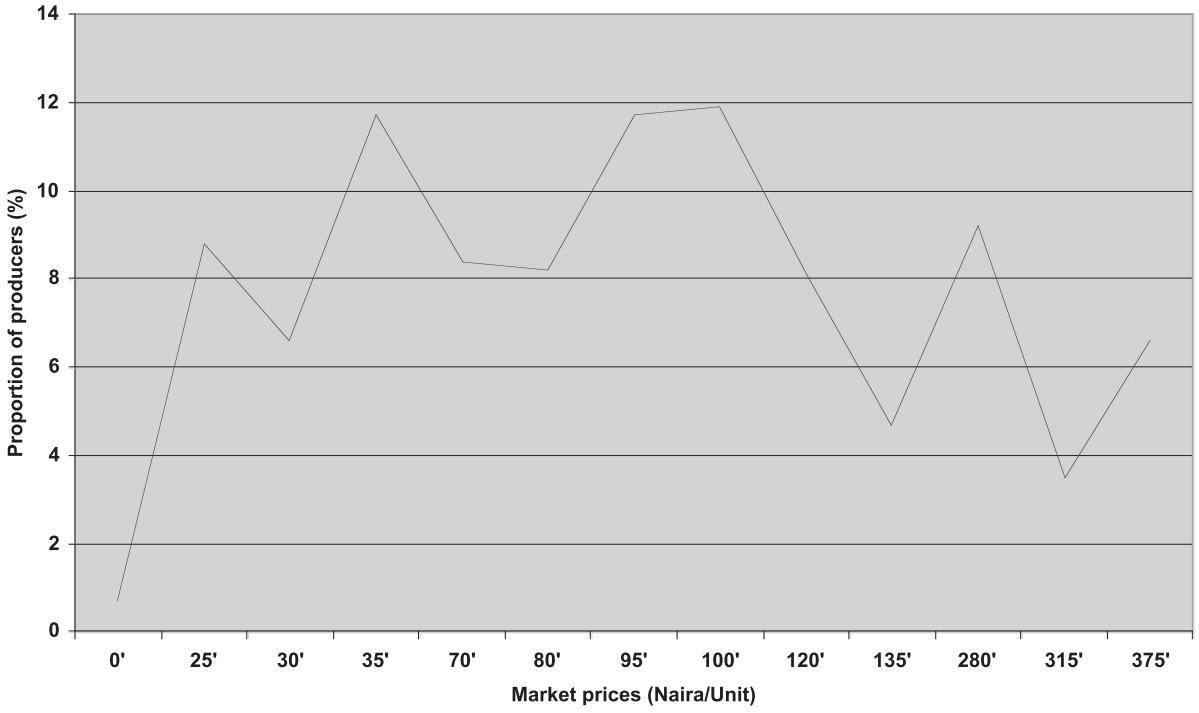

Figure 2. *Producer choices on* Bt *cowpea according to market prices*

The perceptions of consumers are similar in urban zones. About 33% of consumers think that *Bt* cowpea is quite safe for human consumption while 43% reported that it is easy to cook. The willingness to pay for consumers changed according to expected *Bt* cowpea price. Only a small proportion of consumers (16%) were willing to pay a premium of up to 30% over current price of conventional cowpea for *Bt* cowpea (US$ 0.6/kg).

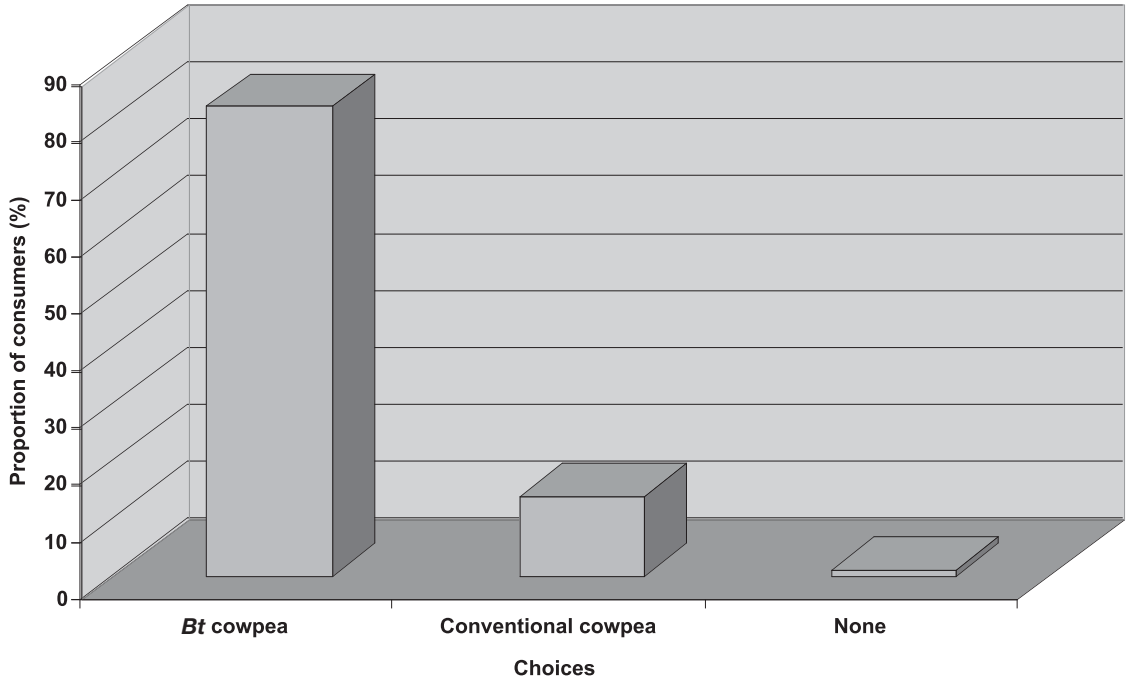

Figure 3. *Rural consumer preferences for cowpea in Nigeria*

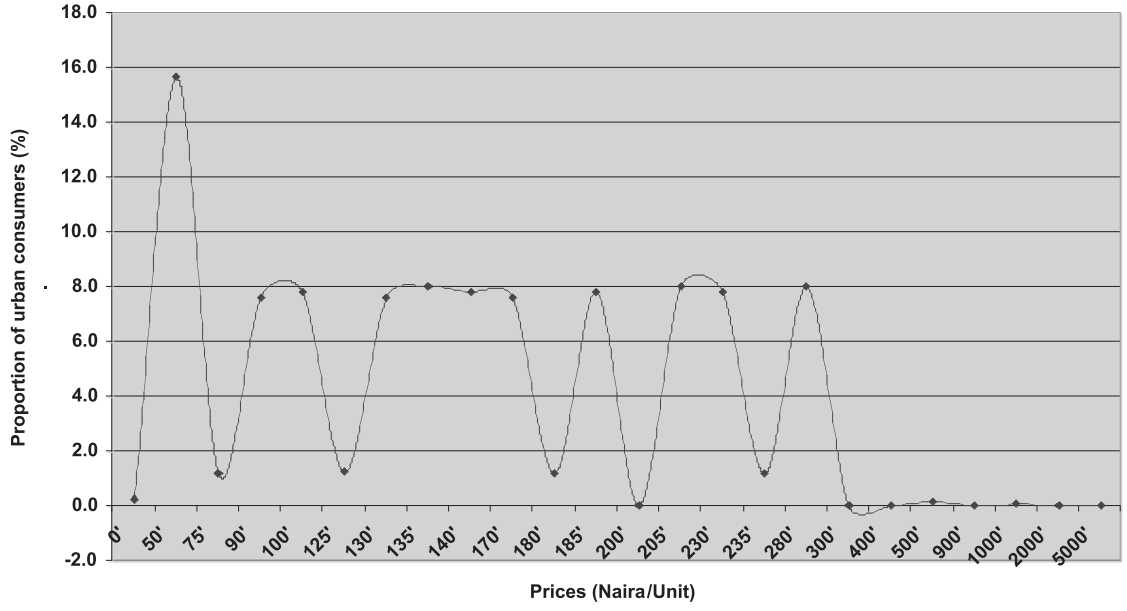

Figure 4. *Urban consumer choices for* Bt *cowpea according to market prices in northern Nigeria*

Given the above assumptions, the average urban consumers in Nigeria would like to pay for *Bt* cowpea. In two out of the three cities where interviews were held, consumers preferred *Bt* to conventional cowpea. For example consumers in Maiduguri would discount *Bt* cowpea while consumers in both Sokoto and Kano liked *Bt* cowpea and were ready to pay a premium for it.

Burkina Faso

Preliminary results for producer perceptions

The awareness of farmers on GM food is quite similar to Nigeria. Twenty three percent (23%) of farmers interviewed were aware of the existence of GM crops and products, especially cotton. Friends and neighbours are key for information diffusion. Fourty two percent (42%) of farmers expect that yields from *Bt* cowpea would be higher than conventional cowpea without pesticide treatment. This is a key incentive for adopting *Bt* cowpea. Twenty five percent (25%) of farmers were willing to pay a premium price of at least 30% over conventional cowpea current price.

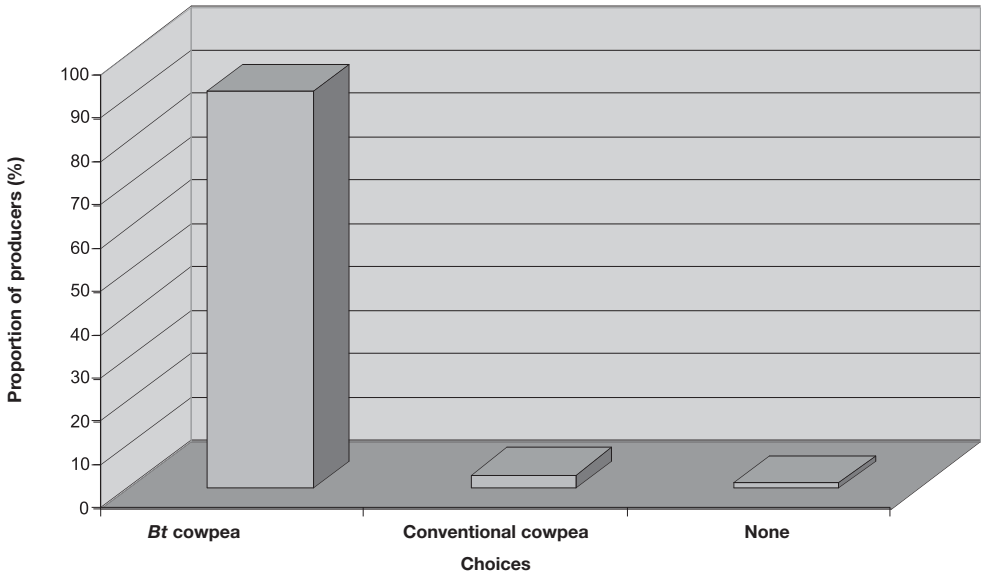

Figure 5. *Producer preferences for cowpea in Burkina Faso*

Preliminary results for consumer perceptions

Consumers in urban zones (42%) were more informed on GM food than rural dwellers. Forty percent (40%) of urban consumers reported that *Bt* cowpea may be easier to cook. The rural communities believe that *Bt* cowpea could be easy to cook compared to conventional cowpea. Thirty five percent (35%) of rural consumers reported that *Bt* cowpea would be safe for human consumption compared to 59% in the urban zone.

Forty two percent (42%) of farmers were convinced that *Bt* cowpea would not require the same level of pesticide spray like conventional cowpea for the same yield level.

The adoption of *Bt* cowpea would lead to a significant reduction of pesticides and hence potential health benefits for both cowpea growers and consumers. The majority of rural consumers (92%) would choose to buy *Bt* cowpea at current conventional cowpea prices. A significant number of rural consumers (23%) were willing to pay a premium of 30% (US$ 0.25/kg) over current prices (US$ 0.80/kg).

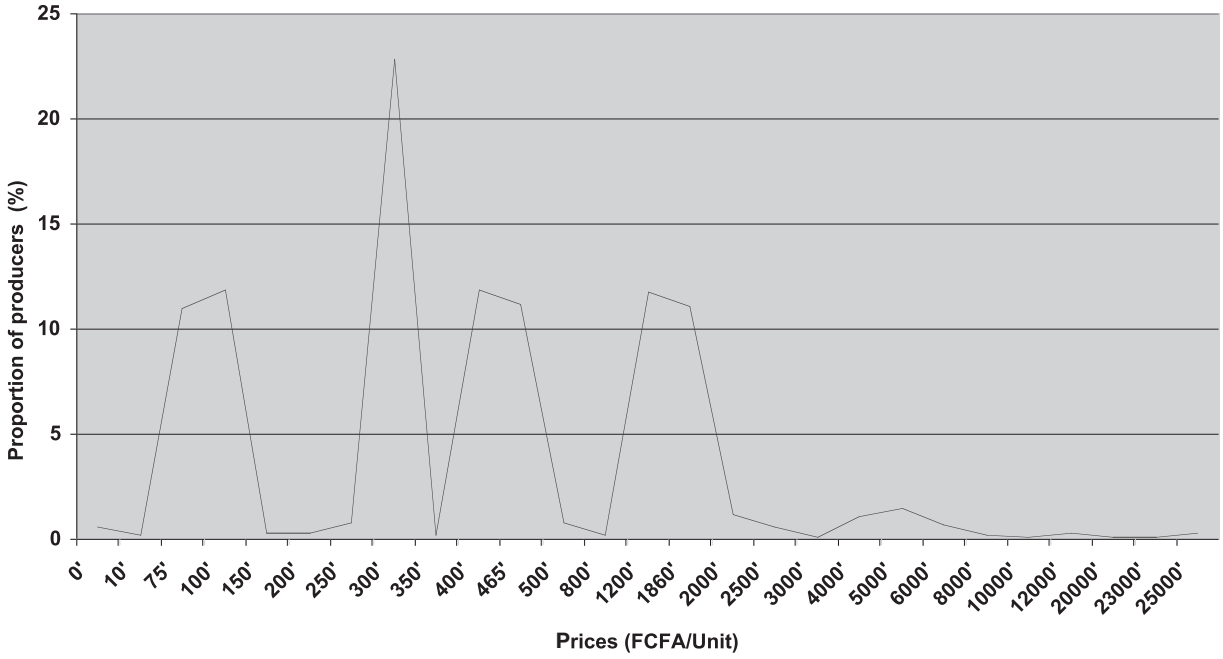

Figure 6. *Producer choices for* Bt *cowpea according to market prices in Burkina Faso*

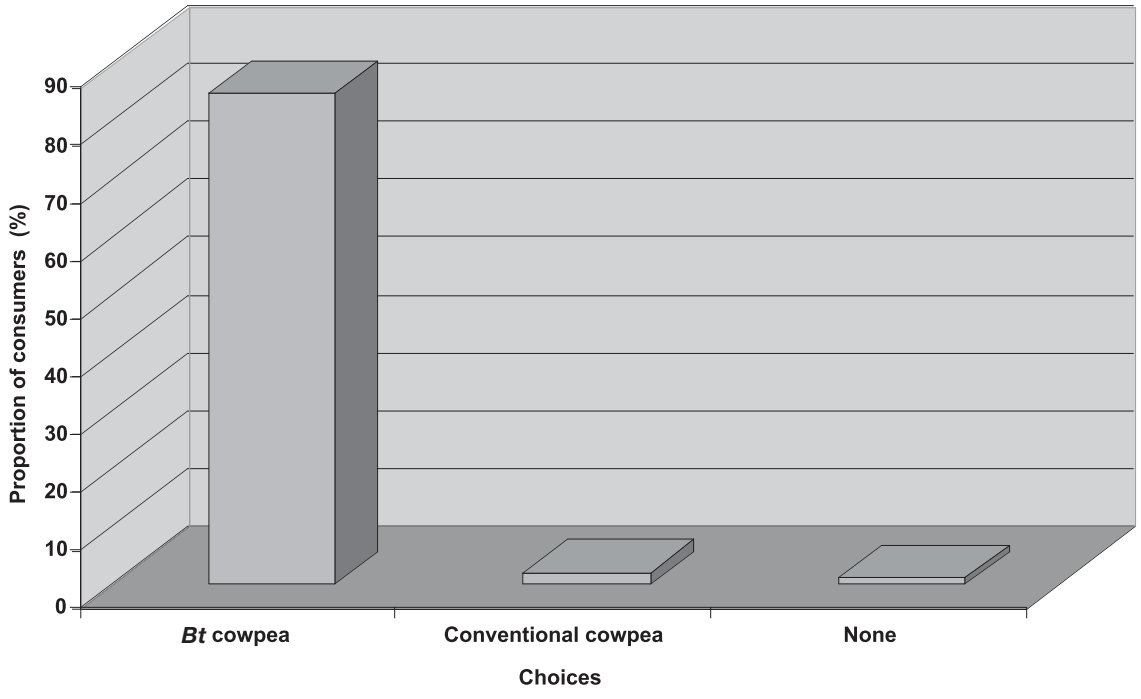

Figure 7. *Rural consumer preferences for cowpea in Burkina Faso*

Niger

Preliminary results for producer perceptions

Cowpea producers (89%) in Niger did not know about GMOs but were willing to use the *Bt* cowpea seed if it could decrease the level of pesticide use compared to conventional cowpea and at the same price (US$ 1/kg).

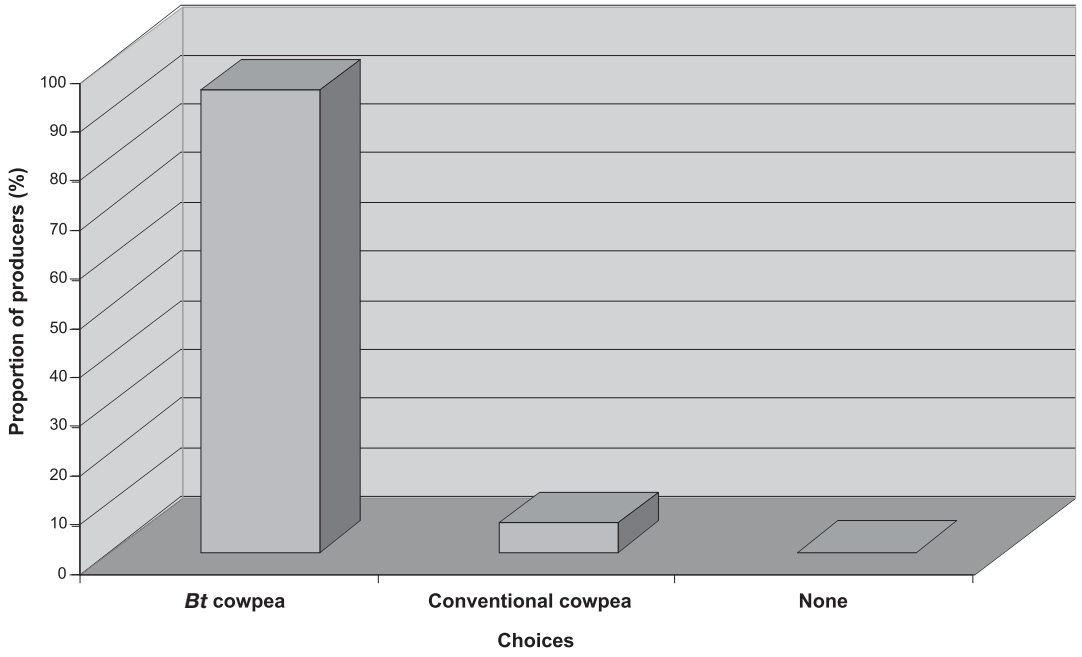

Figure 8. *Producer preferences for cowpea in Niger*

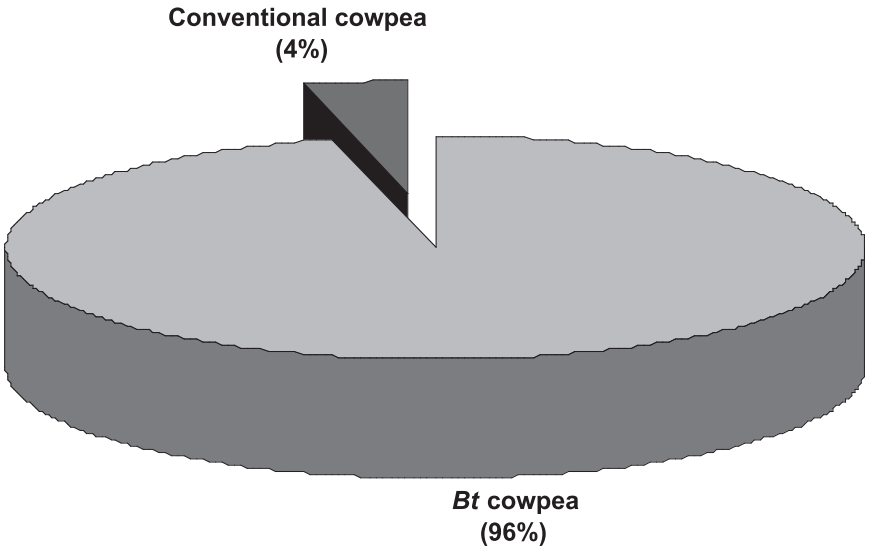

Figure 9. *Farmer preferences following market price simulation in Niger*

Preliminary results for consumers

The average rural consumer who buys cowpea mostly for home consumption tends to prefer *Bt* cowpea whereas a seller is indifferent. The average urban consumer prefers *Bt* cowpea and is ready to pay a premium for it. Lower health risks could explain this behaviour as *Bt* cowpea is considered safer than conventional cowpea.

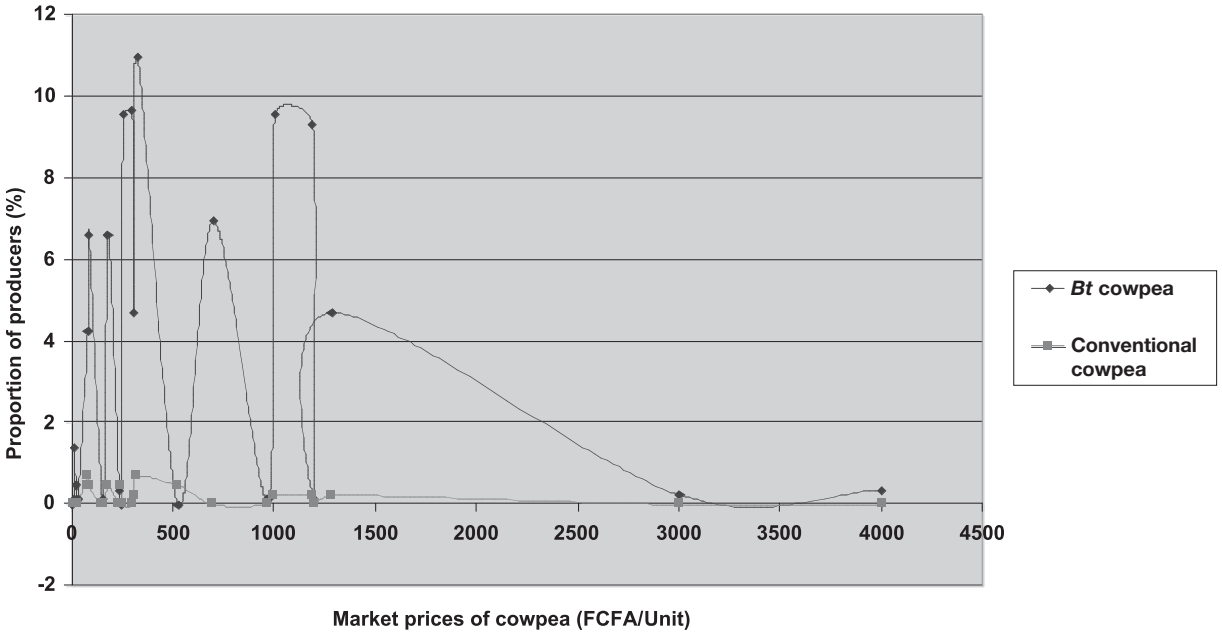

Figure 10. *Producer preferences for cowpea according to market prices in Niger*

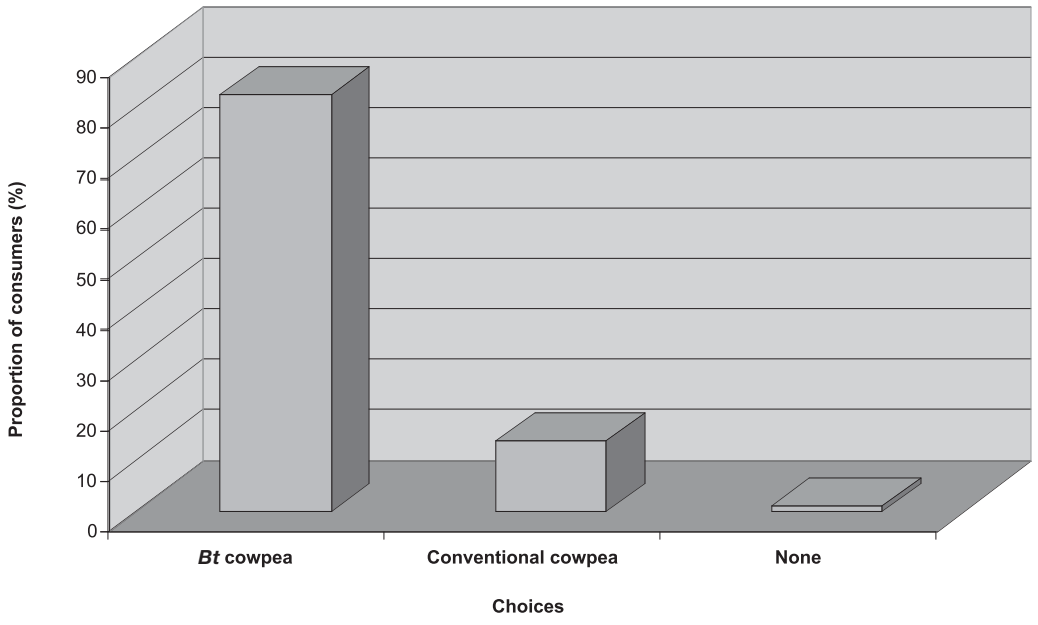

Figure 11. *Rural consumer preferences for cowpea in Niger*

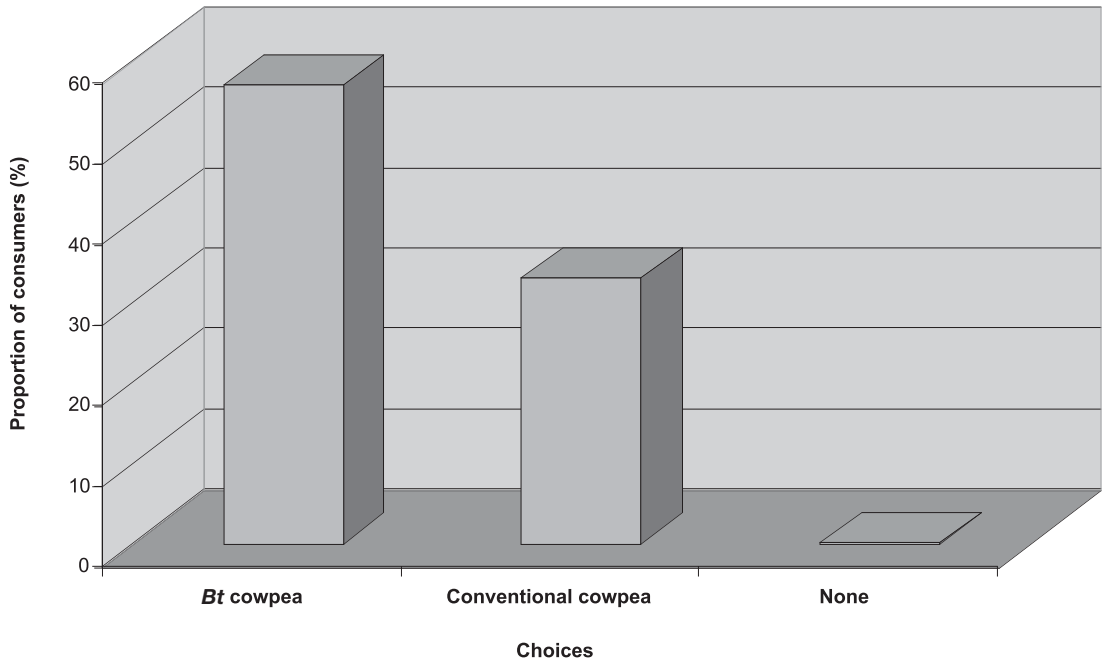

Figure 12. *Urban consumer preferences for cowpea varieties in Niger*

Mali

Preliminary results for producer perceptions

Compared to the other countries studied, more producers (44%) are aware of GM food in Mali. Radio and television are their key sources of information. Many farmers (76%) would adopt *Bt* cowpea seed and are willing to pay a premium price of more than US$ 0.80/kg. This is because *Bt* cowpea is cost effective and safer than conventional

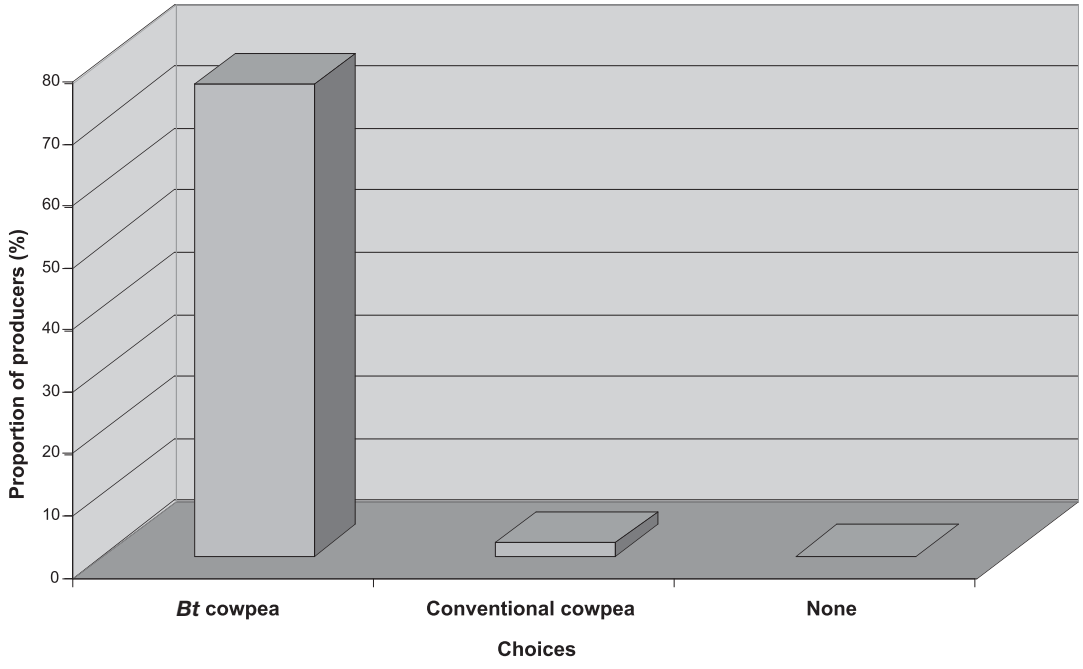

Figure 13. *Producer preferences for cowpea in Mali*

cowpea due to lower pesticide use. Farmers (40%) expected that yields obtained from *Bt* cowpea would be higher than conventional cowpea with no sprays.

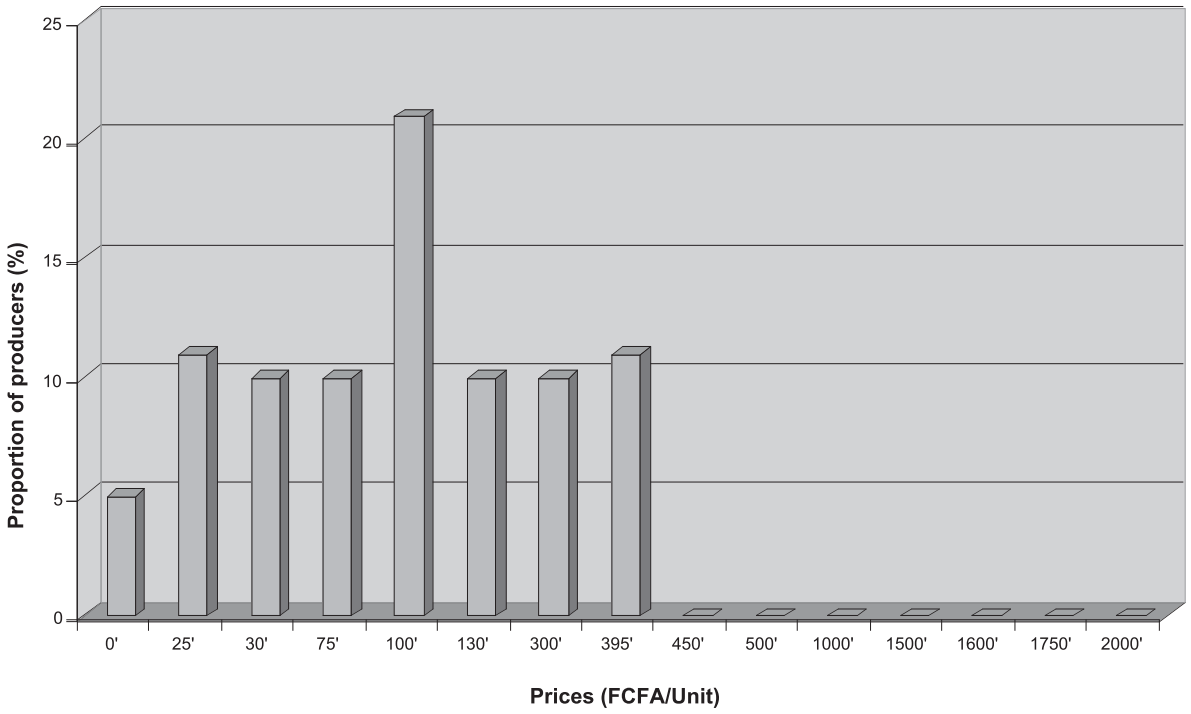

Figure 14. *Producer choices for* Bt *cowpea according to market prices in Mali*

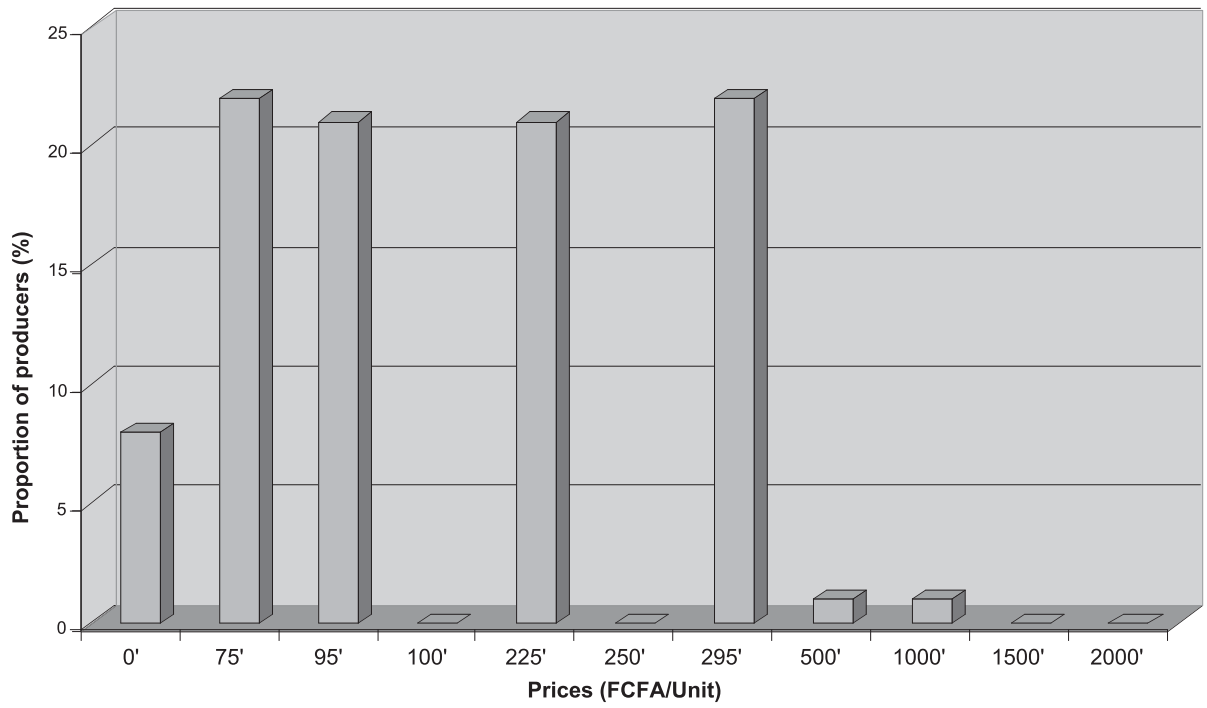

Figure 15. *Producer choices for conventional cowpea according to market prices in Mali*

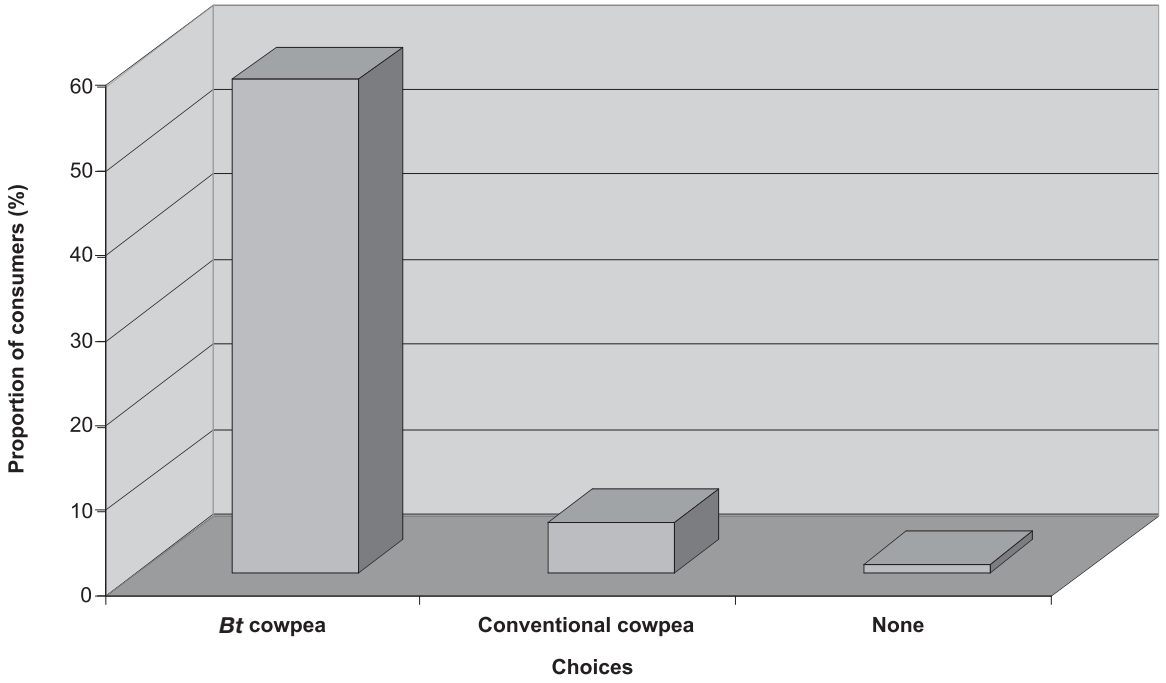

Figure 16. *Urban consumer choices for cowpea in Mali*

Preliminary results for consumers

A small portion of consumers (25% rural and 37% urban) are aware of GM food. Their sources of information are newsletters, and the local radio and television stations. The knowledgeable consumers believe that *Bt* cowpea is safer than conventional cowpea because of lower pesticide use and related risks to human consumption. In rural

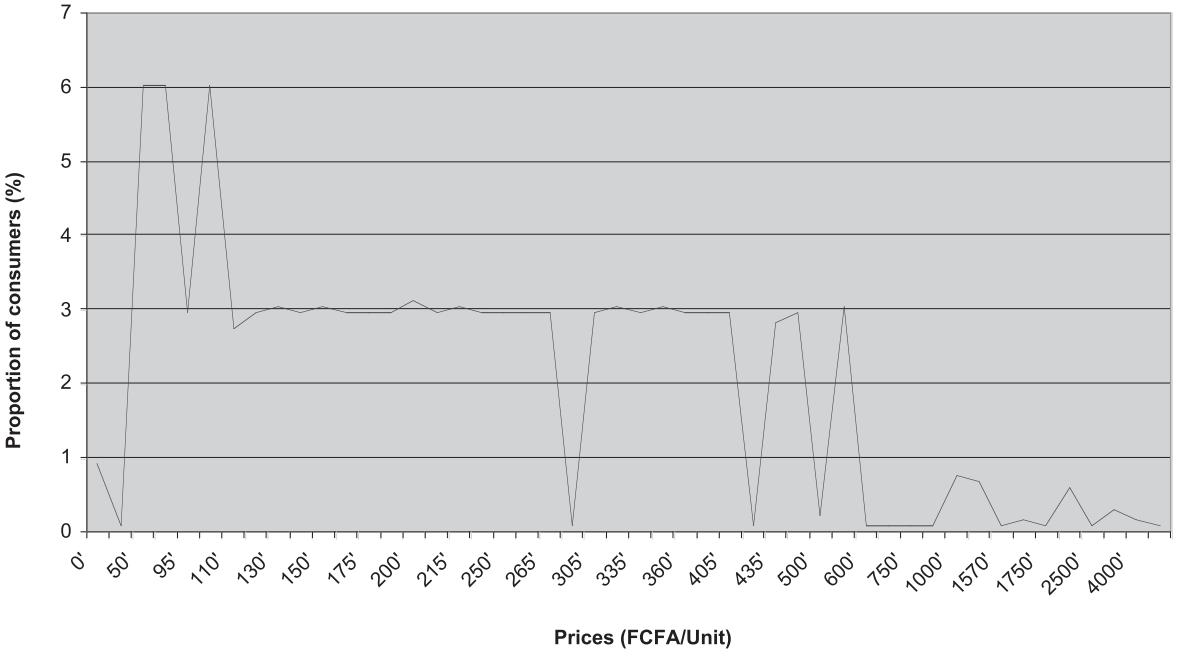

Figure 17. *Urban consumer choices for* Bt *cowpea according to market prices in Mali*

areas, 68% of consumers believe that *Bt* cowpea is safer for human consumption. The majority of urban consumers (99%) were willing to pay for *Bt* cowpea at a price margin of between US$ 0–1/kg.

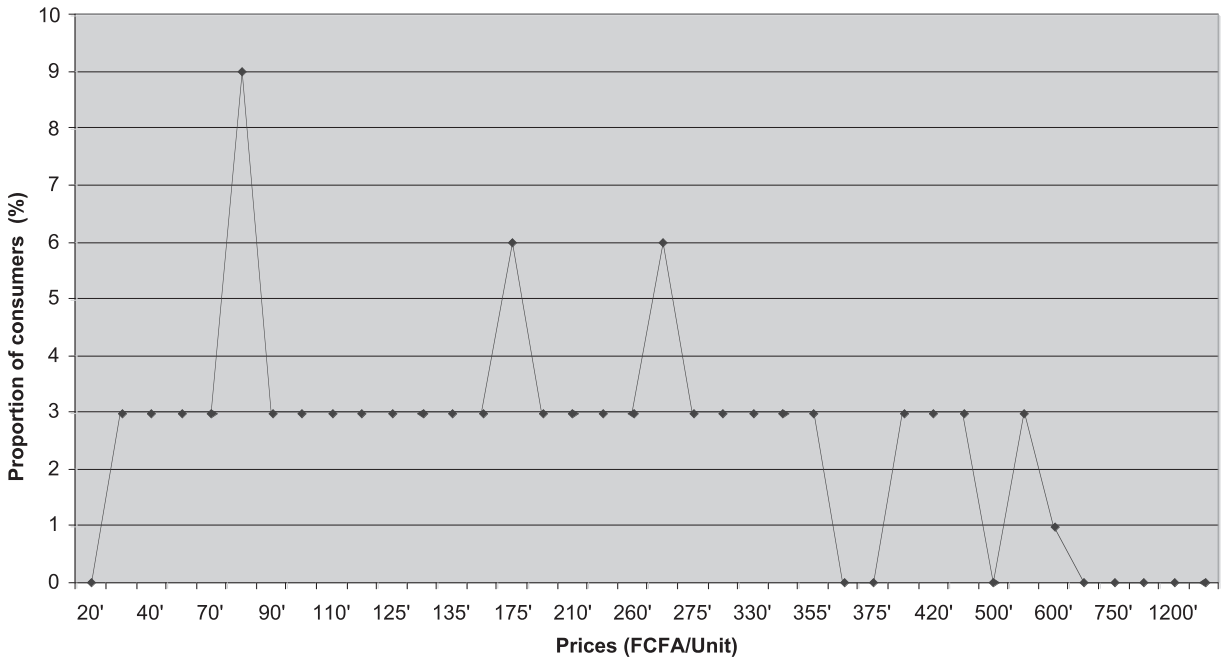

Figure 18. *Rural consumer choices for* Bt *cowpea according to market prices in Mali*

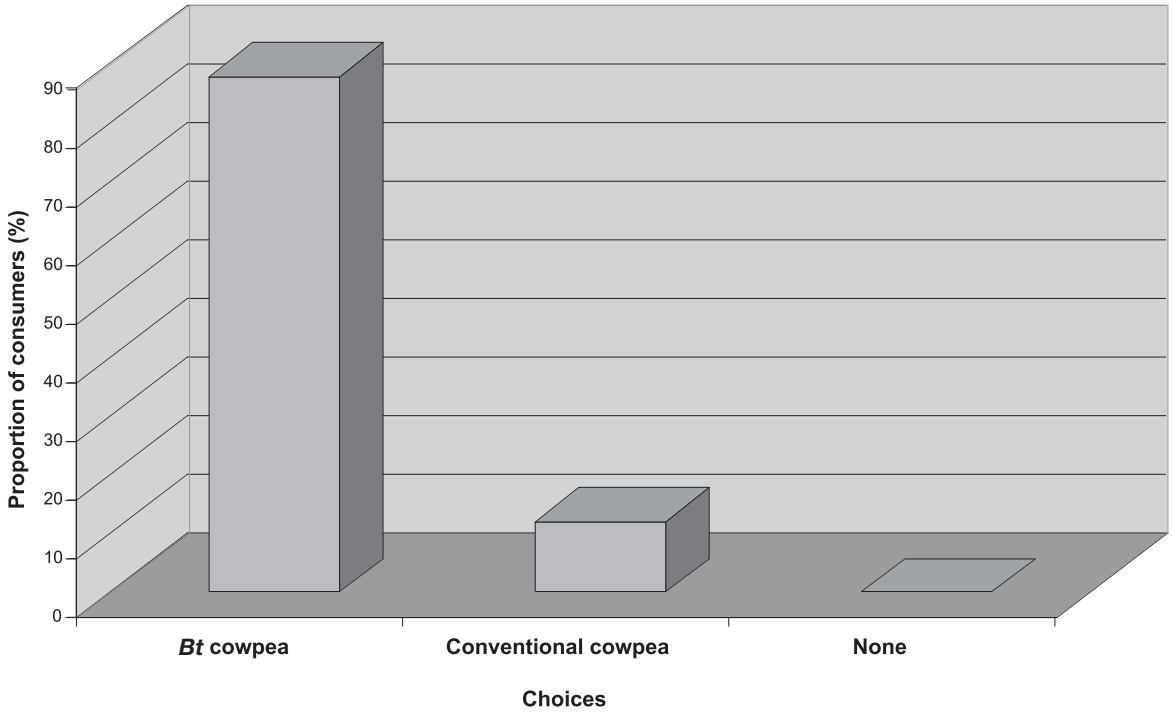

Figure 19. *Rural consumer preferences for cowpea in Mali*

Preliminary results 2: Expected benefits from *Bt* cowpea – draft aggregate results

Gross benefits from *Bt* cowpea in Benin

The results in Table 2 below suggest that *Bt* cowpea would provide an aggregate expected gross benefit estimated at US$ 1.2 billion per year in Benin. This estimate is crude as it is based on the assumption that the seed cost for *Bt* and conventional cowpea are equal (perfect elastic supply curves for both *Bt* and conventional cowpea). However, the unit cost of supplying *Bt* cowpea may be higher than the one of conventional cowpea.

Table 2. Gross benefits from *Bt* cowpea in Benin

Gross benefits from *Bt* cowpea		
Rural producers and consumers	150,523,679,315 FCFA/year	278,376,385 US$/year
Urban consumers	487,848,581,658 FCFA/year	902,220,338 US$/year
Total benefits from *Bt* cowpea in Benin		
	638,372,260,974 FCFA/year	1,180,596,725 US$/year

Gross benefits from *Bt* cowpea in Niger

Results in Table 3 show that the average consumer buying cowpea mostly for resale does not have a preference for any of the types of cowpea and would derive the same level of satisfaction from *Bt* or conventional cowpea. The aggregate results across rural producers and consumers in Niger implies a willingness to pay a premium for *Bt* cowpea, and this translates into a total benefit of US$ 3 billion with the adoption of *Bt* cowpea. Health reasons (*Bt* cowpea is safer than conventional cowpea) could explain the perceptions of the average urban consumer in Niger. The total gains for both producers and consumers with the introduction of *Bt* cowpea would be US$ 3 billion/year.

Table 3. Gross benefits from *Bt* cowpea in Niger

Gross benefits from *Bt* cowpea		
Rural producers and consumers	1,652,306,648,908 FCFA/year	3,055,752,790 US$/year
Urban consumers	52,872,561,407 FCFA/year	97,781,775 US$/year
Total benefits from *Bt* cowpea in Niger		
	1,705,179,210,316 FCFA/year	3,153,534,565 US$/year

Gross benefits from *Bt* cowpea in Nigeria

Table 4 suggests that producers and consumers in Nigeria would experience a welfare gain of about US$ 5.1 billion once *Bt* cowpea is available in Nigerian rural markets. Two reasons could explain why the average rural household in Nigeria tends to prefer *Bt* to conventional cowpea:

- *Bt* cowpea is safer than conventional cowpea in terms of consumption
- *Bt* cowpea would increase the income of the rural farm household and therefore increase its welfare.

Results in Table 4 also suggest a gross welfare gain of about US$ 3.3 billion for all urban consumers in Nigeria once *Bt* cowpea is made available in Nigerian urban markets. This assumption is based on the survey results which were conducted in Kano, Sokoto and Maiduguri. Consumers in Maiduguri tend to discount *Bt* cowpea as opposed to consumers in Kano and Sokoto who on average tend to prefer *Bt* cowpea.

Table 4. Gross benefits from *Bt* cowpea in Nigeria

Gross benefits from *Bt* cowpea		
Rural producers and consumers	658,038,817,706 Naira/year	5,131,907,332 US$/year
Urban consumers	422,491,532,978 Naira/year	3,294,923,244 US$/year
Total benefits from *Bt* cowpea in Nigeria		
	1,080,530,350,684 Naira/year	8,426,830,576 US$/year

Key factors affecting the cost of production of cowpea

Cowpea inputs were divided in tradable and non-tradable (domestic) factors. Domestic factor costs amounted to 87% of the total cost while the tradable factor costs were only 13% (Figure 20). Labour costs accounted for a large share of total costs (Figures 21 and 22). In local farming systems, labour accounted for 69% of total costs compared to 77% in integrated pest management (IPM) farming systems. The IPM practices and technologies such as botanicals were demanding in labour. To resolve the constraint of cash linked to the demand of labour, farmers mainly used family labour and labour of friends (mutual aid). This reduced the labour costs of production from 25% to 50%. The cost of the use of chemical fertiliser and chemical insecticides (most important tradable inputs) in local farming systems, accounted for 10% of total costs compared to 3% in IPM farming systems (Figures 21, 22 and 23).

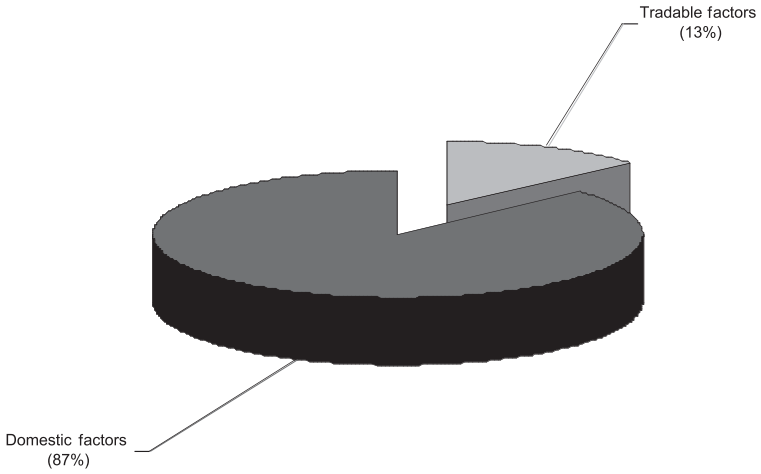

Figure 20. *Proportion of key factors in the total cost of production*

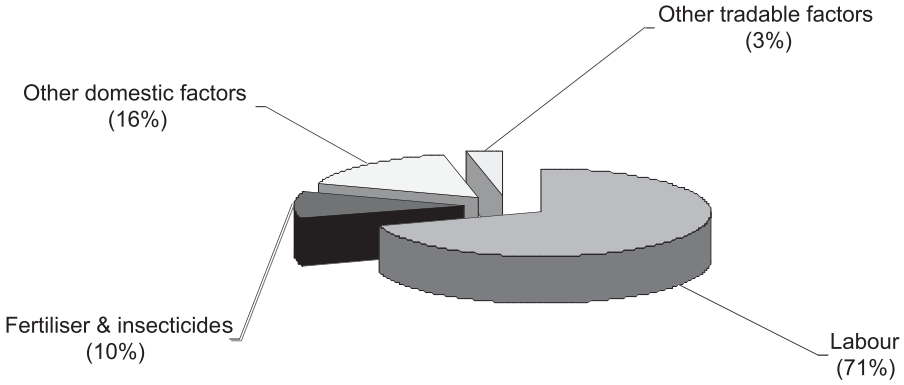

Figure 21. *Proportion of key factors in the total cost of cowpea production: Case of all farming systems*

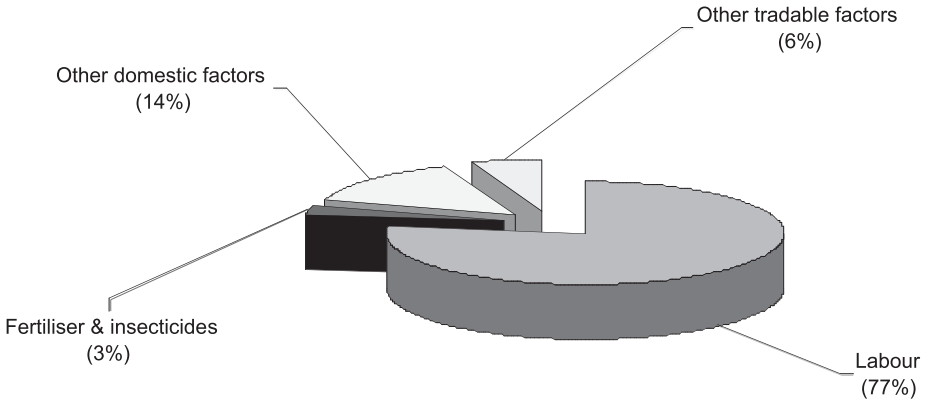

Figure 22. *Proportion of key factors in the total cost of cowpea production: Case of IPM farming systems*

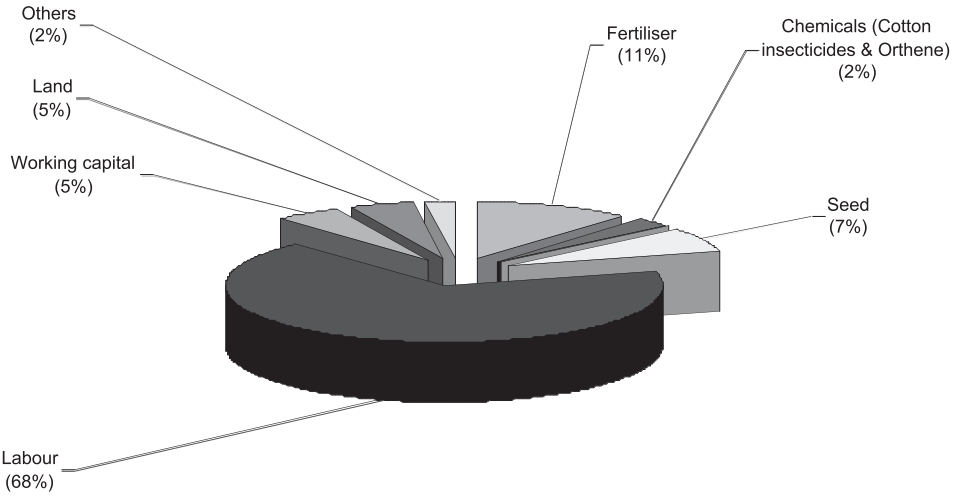

Figure 23. *Proportion of key factors in the total cost of cowpea production: Case of farming systems (farmer practices)*

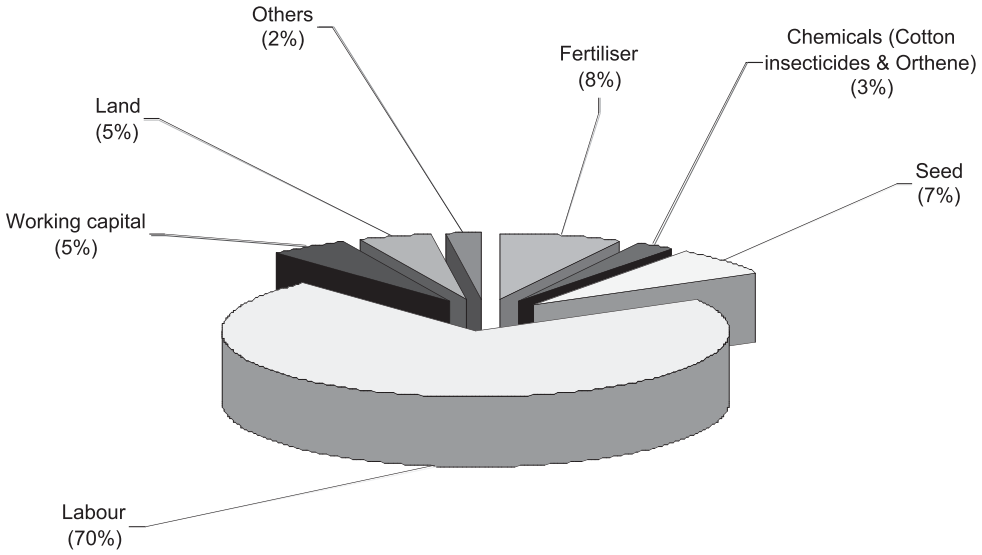

Figure 24. *Proportion of key factors in the total cost of cowpea production: Case of all farming systems*

The use of *Bt* cowpea would reduce the use of chemical insecticides, thus farmers would save on insecticide use costs – purchase and labour costs – assuming that farmers have at least the same yield (Figure 25).

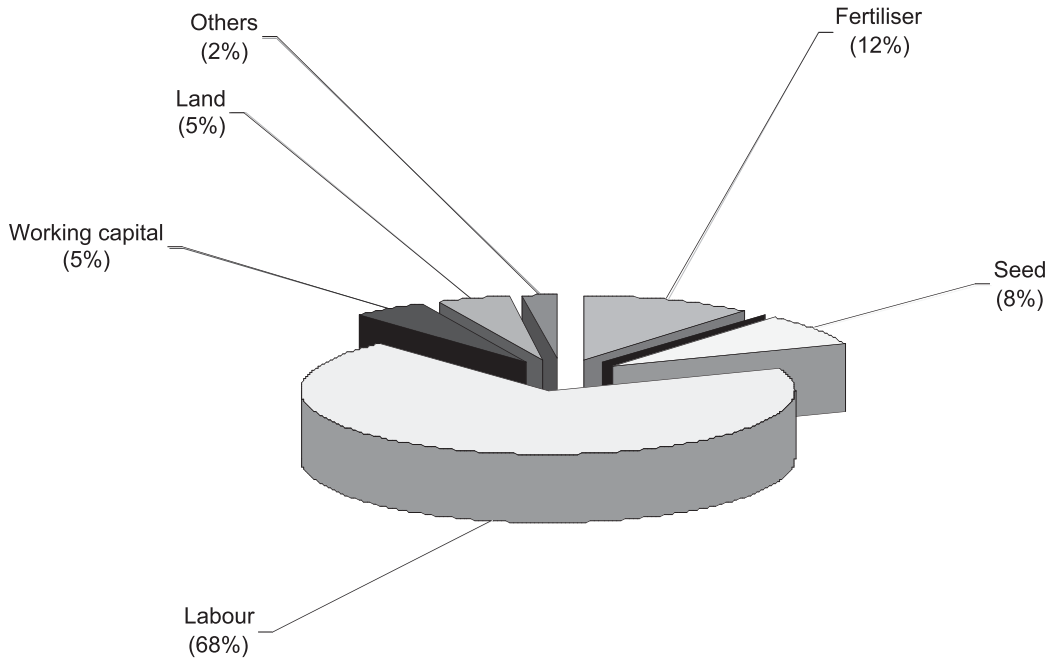

Figure 25. *Proportion of key factors in the total cost of cowpea production: Case of* Bt *cowpea adoption (without chemical use)*

Table 5. Cost-benefit analysis applicable to improved cowpea technologies in Benin

Production systems	Financial net return (US$)	Economic net return (US$)
Improved variety + Botanical pesticide + Local storage	56	141
Local variety + Botanical pesticide + Local storage	-53	14
Local variety + Botanical pesticide + Improved storage	-38	19
Improved variety + Chemical + Local storage	-21	57

Cowpea based systems are profitable only with improved varieties. *Bt* cowpea which is an improved variety will increase significantly the profitability for farmers and also decrease health costs to farmers and consumers.

Conclusion

The results of this study show that the majority of producers and rural consumers are not aware of GM food or GMO products. In urban areas, the level of information and awareness of consumers is much higher. Information exchange, sensitisation and awareness are important elements for the adoption and large diffusion of *Bt* cowpea when developed. The average farmer is willing to pay a higher price for *Bt* cowpea seed as it would reduce chemical pesticide use and/or solve its non-availability. Expectations are that *Bt* cowpea would reduce potential health hazards to both farmers and consumers by reducing the use of harmful cotton pesticides. Health benefits will be linked to the reduction in health costs and/or a decrease in the use of harmful cotton insecticides. An average urban consumer believes that *Bt* cowpea would be safer. *Bt* cowpea will significantly increase the profitability for farmers.

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Annexes

Annex I

Benin

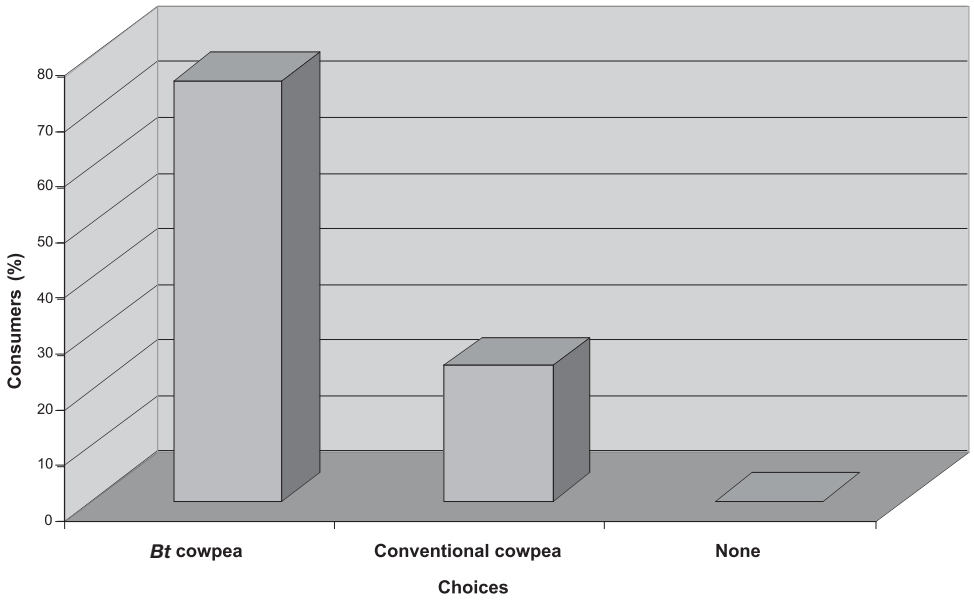
Sampling framework in Benin

Country zones covered	Departments	Villages and towns	Target groups selected
Northern Benin	Alibori	Gounarou	Producers
		Kantakpara	Producers
		Soukarou	Producers
		Boro	Producers
		Malanville	Urban consumers
		Village near Malanville	Rural consumers
	Borgou	Parakou	Urban consumers
		Village near Parakou	Rural consumers
Central Benin	Collines	Katakou	Producers
		Longbondjin	Producers
		Akomian	Producers
		Ayekoffowin	Producers
		Glazoue	Rural consumers
		Dassa	Urban consumers
Southern Benin	Oueme	Gogbo	Producers
		Gbekandji 1	Producers
		Gbekandji 2	Producers
		Agonlin	Producers
		Adjarra	Rural consumers
		Porto-novo	Urban consumers
	Plateau	Ketou	Rural consumers
		Pobe	Rural consumers
	Littoral/Atlantique	Cotonou	Urban consumers
		Glo-djigbe	Rural consumers

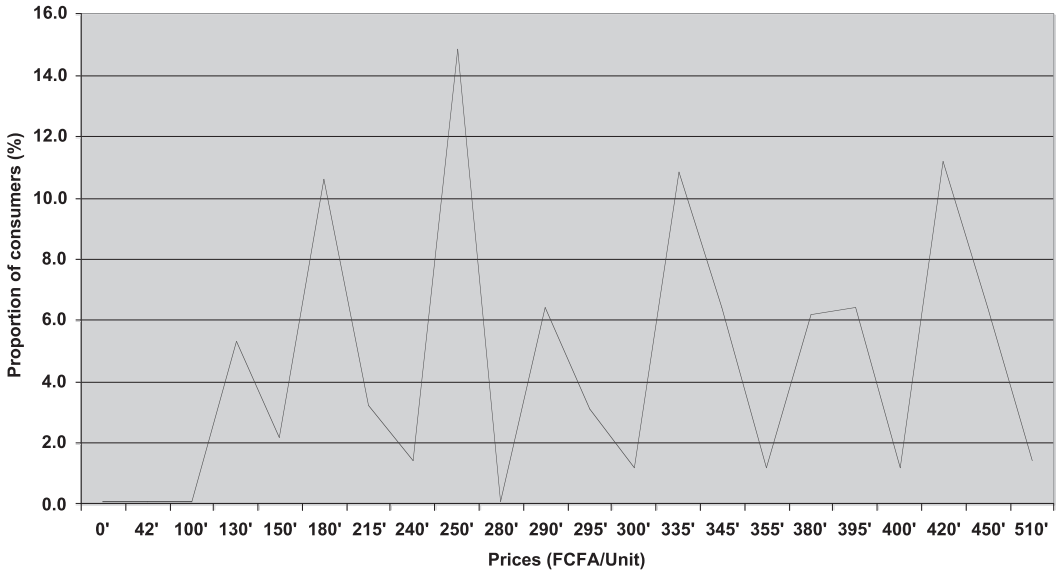
Rural consumers in Benin

Rural consumer awareness on GM food in Benin

Answers	Frequency	Percentage
No	236	99
Yes	1	1
Total	237	100

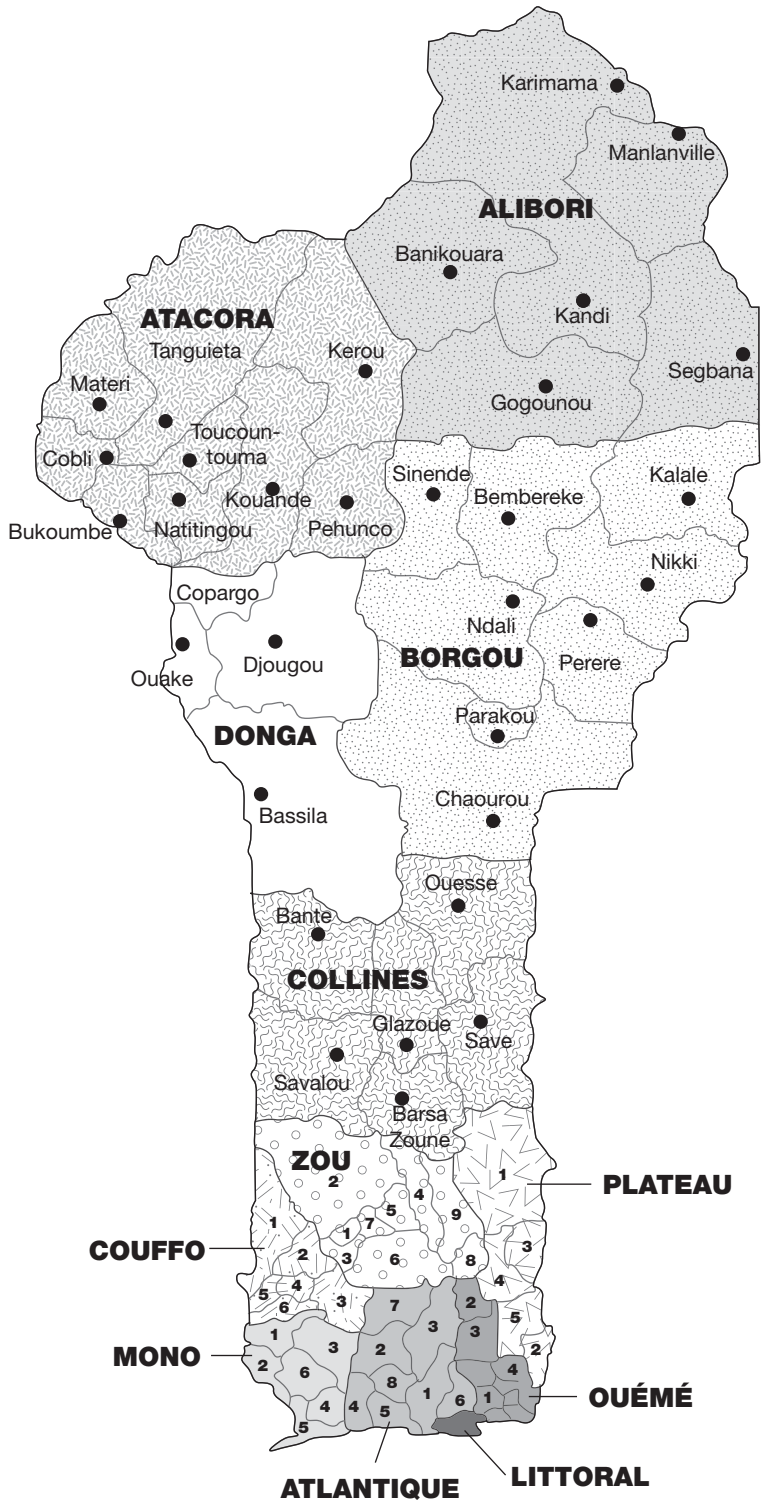


Rural consumer choices of cowpea in Benin



Proportion of rural consumers who chose conventional cowpea according to given prices in Benin

Administrative map of Benin



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Niger

Sampling framework in Niger

Zones	Depart-ments/ Regions	Villages and towns	Characteristics of agro-ecological zones	Target group selected
Central Niger	Tahoua	Kao 1	1 rain season	Producers
		Kao 3	1 rain season	Producers
		Eguede	1 rain season	Producers
		Idouk	1 rain season	Producers
Southern Niger	Zinder	Anguoal–Gamdji 1 (Magaria)	1 rain season	Producers
		Anguoal–Gamdji 2 (Magaria)	1 rain season	Producers
	Maradi	Maradi	1 rain season	Urban consumers
		Guidantangnon	1 rain season	Producers
		Kodao	1 rain season	Producers
	Niamey region	Niamey	1 rain season	Urban consumers
		Kollo	1 rain season	Rural consumers

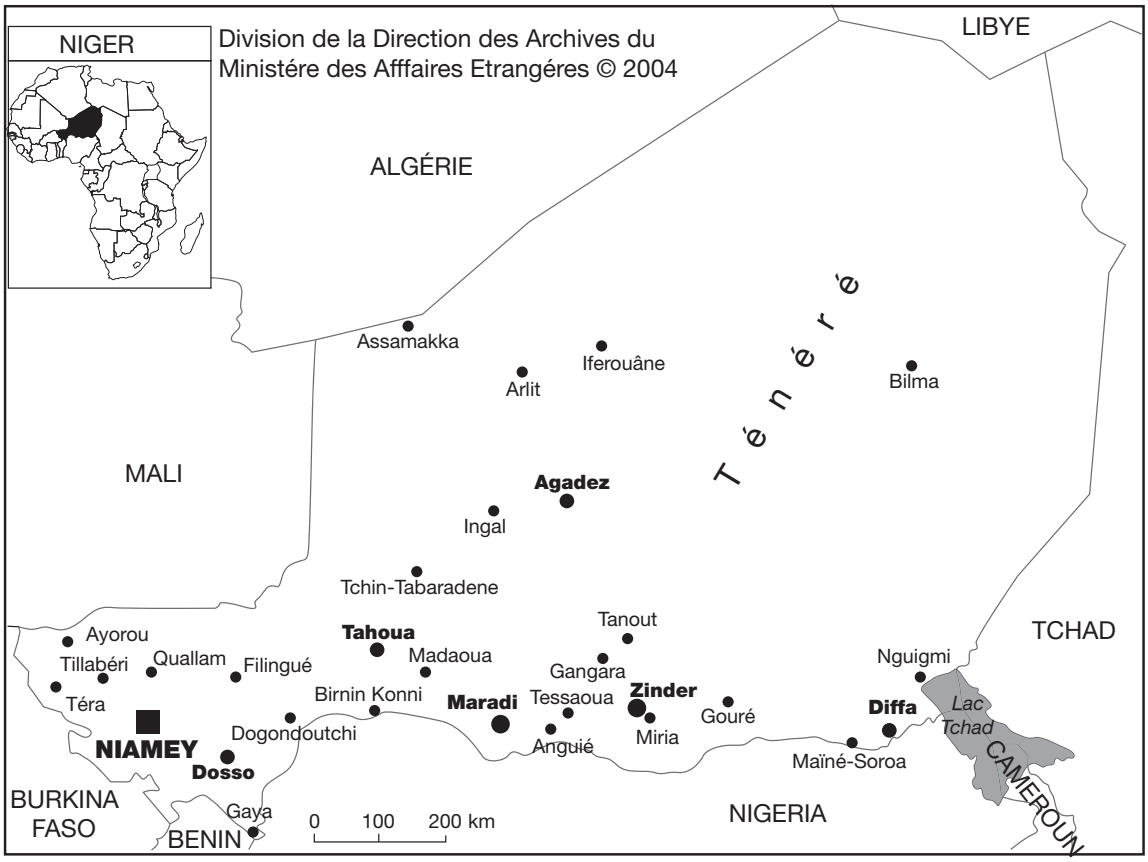
Urban consumer perceptions in Niger

Key questions	Answers	Frequency	Percentage
Have you ever heard of Genetically Modified (GM) food?	No	63	79
	Yes	17	21
	Total	80	100
If the answer to the preceding question is yes, where did you hear about it?	TV – CNN, TV5, ORTN	4	5
	RADIO RFI, National	13	16
	Friends and neighbours	2	3
	Other	3	4
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very safe for human consumption	50	63
	Quite safe for human consumption	14	18
	Safe for human consumption	7	9
	Not that safe for human consumption	6	8
	Not safe at all for human consumption	1	1
Do you think that conventional cowpea is:	Very safe for human consumption	32	40
	Quite safe for human consumption	19	24
	Safe for human consumption	20	25
	Not that safe for human consumption	8	10
	Not safe at all for human consumption	80	100
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very easy to cook	37	46
	Quite easy to cook	20	25
	Easy to cook	15	19
	Difficult to cook	5	6
	Quite difficult to cook	1	1
	Very difficult to cook	0	0
Do you think that conventional cowpea is:	Very easy to cook	40	50
	Quite easy to cook	14	18
	Easy to cook	17	21
	Difficult to cook	3	4
	Quite difficult to cook	2	3
	Very difficult to cook	1	1

Rural consumer perceptions in Niger

Key questions	Answers	Frequency	Percentage
Have you ever heard of Genetically Modified (GM) food? (Yes or No)	Yes	9	12
If the answer to the preceding question is yes, where did you hear about it?	Radio – BBC	6	8
	Radio – Deutsche Welle	1	1
	Journal – Other media document	1	1
	Other (ORTN)	3	4
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very safe for human consumption	57	73
	Quite safe for human consumption	9	12
	Safe for human consumption	5	6
	Not that safe for human consumption	3	4
	Not safe at all for human consumption	1	1
Do you think that conventional cowpea is:	Very safe for human consumption	26	33
	Quite safe for human consumption	29	37
	Safe for human consumption	10	13
	Not that safe for human consumption	9	12
	Not safe at all for human consumption	1	1
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very easy to cook	32	41
	Quite easy to cook	22	28
	Easy to cook	12	15
	Difficult to cook	5	6
	Quite difficult to cook	3	4
	Very difficult to cook	3	4
Do you think that conventional cowpea is:	Very easy to cook	34	44
	Quite easy to cook	21	27
	Easy to cook	13	17
	Difficult to cook	5	6
	Quite difficult to cook	1	1
	Very difficult to cook	0	0

Map of Niger



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Nigeria

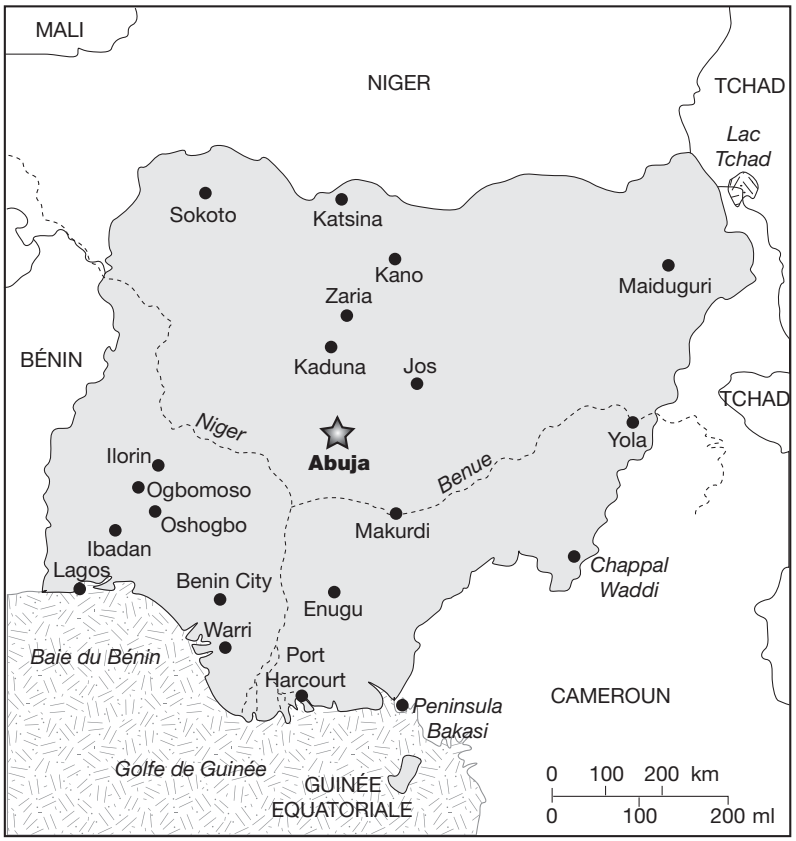
Sampling framework in Nigeria

Zones	States	Villages and towns	Target group selected
Northern Nigeria	Kano	Kano	Urban consumers
		Dambatta	Producers
		Rano	Producers
		Gaya	Producers
	Kaduna	Zaria	Producers
			Producers
			Producers
			Producers
	Sokoto		Urban consumers
	Borno	Maiduguri	Producers

Agricultural practices and characteristics of cowpea producers

Key questions	Answers	Frequency	Percentage
Do you plant cowpea? (Yes or No)	Yes	173	99
Which cowpea variety do you plant mostly?	White	118	68
	Red	1	1
	Brown	59	34
Which type of cowpea seed do you usually plant?	Local variety conserved at home	116	67
	Local variety bought in the market	47	27
	Improved varieties conserved at home	6	3
	Improved varieties bought in the market	2	1
	Improved seed bought at the direction of agriculture	3	2
Do you usually use chemical insecticide with cowpea? (Yes or No)	Yes	146	84
If the response to the preceding question is yes, when do you usually buy chemical insecticide for cowpea?	Beginning of cropping season	85	49
	After observing insect infestation in cowpea	59	34
Which type of chemical insecticide do you usually buy for cowpea?	Cotton chemical insecticide	1	1
	Unlabelled chemical insecticide bought on the informal market	14	8
	Recommended chemical insecticide for cowpea	126	72
	Other (specify)	4	2
According to you, access to agricultural loans is:	Very easy	3	2
	Quite easy	5	3
	Easy	3	2
	Quite difficult	65	39
	Very difficult	75	44
	Impossible access	13	8
Have you had any direct contact/support with development associations, NGOs and/or governmental extension services within the last 10 years? (Yes or No)	Yes	96	55
According to you, access to activities on agricultural vulgarisation is:	Very easy	36	21
	Quite easy	31	18
	Easy	43	25
	Quite difficult	30	17
	Very difficult	21	12
	Impossible access	11	6
According to you, access to the sellers of agricultural input in the region is:	Very easy	53	31
	Quite easy	38	22
	Easy	48	30
	Quite difficult	6	4
	Very difficult	14	8
Does your household perceive non-agricultural income? (Yes or No)	Yes	61	35

Map of Nigeria



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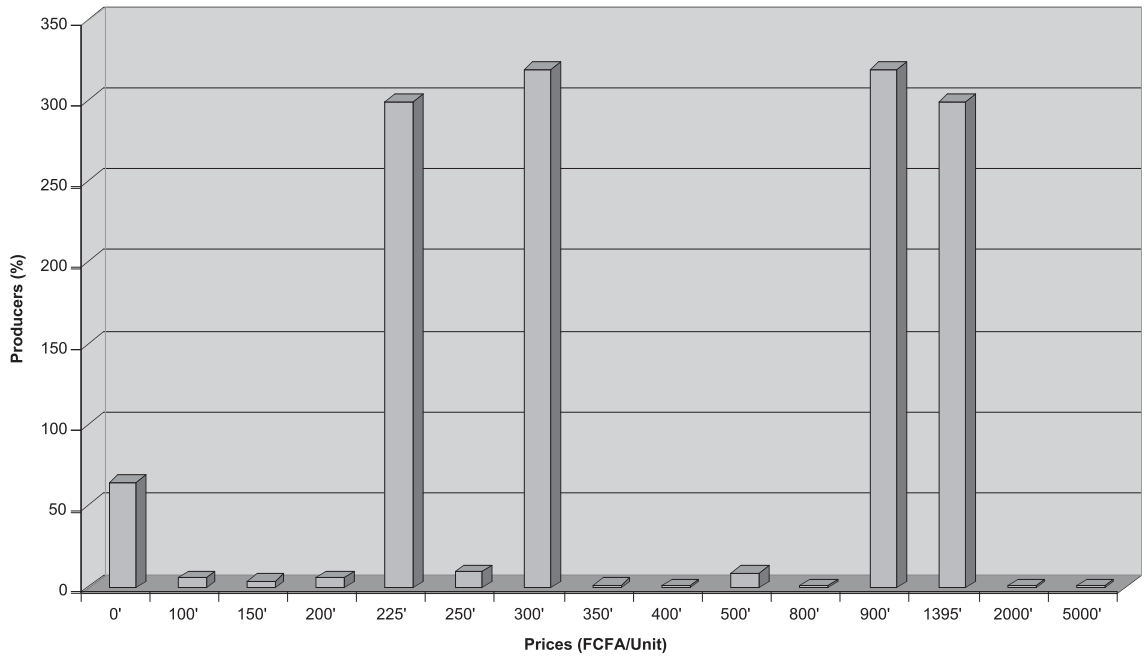
Burkina Faso

Sampling framework in Burkina Faso

Agro-ecological zones	Provinces	Villages and towns	Target group selected
Sahel	Pobe Mengao	Goue	Rural consumers
		Niamanga	Producers
		Pobe Mengao	Producers
		Somnawaye	Producers
		Toumba	Producers
Sudan	Loumbila	Ouagadougou	Urban consumers
		Bobo-Dioulasso	Urban consumers
		Bougue	Rural consumers
		Donsin	Producers
		Gargaboule	Producers
		Katenga	Producers
		Debere	Producers

Proportion of rural consumers who chose conventional cowpea according to the market prices in Burkina Faso

Prices (FCFA/Unit)	Frequency	Percentage	Valid percentage	Cumulative percentage
0	65	4.8	4.8	4.8
100	6	0.4	0.4	5.3
150	4	0.3	0.3	5.6
200	6	0.4	0.4	6.0
225	300	22.1	22.3	28.3
250	10	0.7	0.7	29.0
300	320	23.6	23.8	52.8
350	2	0.1	0.1	53.0
400	1	0.1	0.1	53.0
500	9	0.7	0.7	53.7
800	1	0.1	0.1	53.8
900	320	23.6	23.8	77.6
1395	300	22.1	22.3	99.9
2000	1	0.1	0.1	99.9
5000	1	0.1	0.1	100.0
Total	1346	99.2	100.0	



Producer choices of conventional cowpea according to market prices in Burkina Faso

Producer awareness and sources of information on GM food

Key questions	Answers	Frequency	Percentage
Awareness on GM food	No	121	77
	Yes	37	23
	Total	158	100
Sources of information	FM Radio Nationale	8	5
	Friends and neighbours	13	8
	Extension agents	6	4
	Training programs	1	0.6
	Farmer associations	2	1
	INERA (Research institute)	3	2
	NGO–ASK (Association Song-Koadba)	6	4

Producer perceptions on *Bt* cowpea compared to conventional cowpea in Burkina Faso

Key questions	Answers	Frequency	Percentage
If you do not use chemical insecticides with cowpea, would you say that the health problems that these insecticides are currently causing within your household are:	Very grave	11	7
	Quite grave	43	27
	Grave	34	22
	Not really grave	34	22
	No problem at all	17	11
If you use chemical insecticides with cowpea, do you think that, with *Bt* cowpea (as I have described it to you), the health problems that chemical insecticides cause within your household would be:	Very grave	6	4
	Quite grave	1	0.6
	Grave		
	Not really grave	48	30
	No problem at all	66	42
If you do not use chemical insecticides with cowpea, the yield you o*Bt*ain with conventional cowpea is:	Very high	29	18
	Quite high	1	0.6
	High	2	1.3
	Quite low	43	27
	Low	42	27
	Very low	39	25
If you do not use chemical insecticides with cowpea, do you think that your yield with *Bt* cowpea (as I have described it to you) would be:	Very high	33	21
	Quite high	67	42
	High	39	25
	Quite low	21	13
	Low	12	8
	Very low	5	3

Urban consumer perceptions on GMO in Burkina Faso

Key questions	Answers	Frequency	Percentage
Knowledge on GMO	Yes	33	42
	No	46	58
	Total	79	100
Sources of information on GMO	TV – Local	16	20
	TV – National	5	6
	National radio	4	5
	Journal and other papers	2	3
	Friends and neighbours	3	4
	Others (Market, school, training, conference)	6	8
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very safe for human consumption	47	59
	Quite safe for human consumption	16	20
	Safe for human consumption	10	13
	Not that safe for human consumption	5	6
	Not safe at all for human consumption	2	3
Do you think that conventional cowpea is:	Very safe for human consumption	12	15
	Quite safe for human consumption	19	24
	Safe for human consumption	16	20
	Not that safe for human consumption	15	19
	Not safe at all for human consumption	6	8
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very easy to cook	5	6
	Quite easy to cook	33	41
	Easy to cook	25	31
	Difficult to cook	13	16
	Quite difficult to cook	2	3
	Very difficult to cook	2	3
Do you think that conventional cowpea is:	Very easy to cook	12	15
	Quite easy to cook	11	14
	Easy to cook	22	28
	Difficult to cook	22	28
	Quite difficult to cook	4	5
	Very difficult to cook	4	5

Map of Burkina Faso

Reproduced from: http://www.theodora.com/maps/burkina_map.html

Mali

Sampling framework in Mali

Agro-ecological zones	Regions	Villages and towns	Target group selected
Sudan	Ségou	Ségou	Urban consumers
		Touna	Rural consumers
		Cinzana	Producers
		Sanogola	Producers
		Fambougou	Producers
		Kordogola	Producers
Sahelian	Mopti	Mopti Digue	Urban consumers
		Bankass	Rural consumers
		Kopora Na	Producers
		Youdio	Producers
		Oro	Producers
		Berely	Producers

Producer perceptions on *Bt* cowpea compared to conventional cowpea in Mali

Key questions	Answers	Frequency	Percentage
If you do not use chemical insecticides with cowpea, would you say that the health problems that these insecticides are currently causing within your household are:	Very grave	53	33
	Quite grave	2	1.3
	Grave	14	9
	Not really grave	9	6
	No problem at all	52	32
If you use chemical insecticides with cowpea, do you think that, with *Bt* cowpea (as I have described it to you), the health problems that chemical insecticides cause within your household would be:	Very grave	1	0.6
	Quite grave	0	0
	Grave	4	3
	Not really grave	42	26
	No problem at all	81	50
If you do not use chemical insecticides with cowpea, the yield you o*Bt*ain with conventional cowpea is:	Very high	3	2
	Quite high	6	4
	High	41	25
	Quite low	25	15
	Low	67	41
	Very low	21	13
If you do not use chemical insecticides with cowpea, do you think that your yield with *Bt* cowpea (as I have described it to you) would be:	Very high	53	33
	Quite high	43	26
	High	22	14
	Quite low	39	24
	Low	5	3
	Very low	0	0

Perception of producers given market prices of *Bt* cowpea in Mali

Prices (FCFA/Unit)	Frequency	Percentage
0	75	5
25	166	11
30	160	10
75	160	10
100	331	21
130	161	10
300	159	10
395	166	11
450	1	0
500	2	0
1000	6	0
1500	1	0
1600	3	0
1750	3	0
2000	4	0
2500	35	2
3000	5	0
3500	1	0
4000	5	0
4500	1	0
5000	108	7
6000	10	1
7000	1	0
Total	1564	100

Rural consumer perceptions on *Bt* cowpea in Mali

Key questions	Answers	Frequency	Percentage
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very safe for human consumption	49	68
	Quite safe for human consumption	17	24
	Safe for human consumption	0	0
	Not that safe for human consumption	2	3
	Not safe at all for human consumption	1	1
Do you think that conventional cowpea is:	Very safe for human consumption	8	11
	Quite safe for human consumption	9	13
	Safe for human consumption	29	40
	Not that safe for human consumption	26	36
	Not safe at all for human consumption	0	0
Do you think that *Bt* cowpea, as I have described it to you, should be:	Very easy to cook	17	24
	Quite easy to cook	13	18
	Easy to cook	24	33
	Difficult to cook	2	3
	Quite difficult to cook	2	3
	Very difficult to cook	1	1
Do you think that conventional cowpea is:	Very easy to cook	27	38
	Quite easy to cook	22	31
	Easy to cook	14	19
	Difficult to cook	7	10
	Quite difficult to cook	2	3
	Very difficult to cook	0	0

Map of Mali

Reproduced from: http://geography.about.com/library/cia/blcmali.htm

Annex II: Institutions visited during the data collection

Institutions visited in Benin, Niger, Nigeria, Burkina Faso and Mali were research institutions, development projects, NGOs, policy makers (ministry) and the private sector.

The following institutes were visited to collect secondary data in the various countries.

Benin

- Ministère de l'Agriculture, de l'Elevage et de la Pêche (MAEP)
- Office National pour l'Approvisionnement et la Sécurité Alimentaire (ONASA)
- Regional extension services: Centre Régional pour la Promotion Agricole (CerPA)-Zou/Collines; CerPA-Borgou/Alibori

Niger

- Département de Recherche en Economie Rurale (DECOR) de l'Institut National de la Recherche Agronomique du Niger (INRAN)
- Direction Générale de l'Agriculture
- Système d'Information des Marchés Agricoles (SIMA)
- AGRIMEX
- Service de météo

Nigeria

- Agricultural Development Programs (ADPs) in Kano, Sokoto, Maiduguri and Jigawa
- Ahmadou Bello University in Zaria
- The Projects Coordinating Unit (PCU), Federal Ministry of Agriculture and Rural Development

Burkina Faso

- Institut de l'Environnement et de Recherches Agricoles (INERA)

Mali

- Economie des Filières de l'Institut d'Economie Rurale (ECOFIL/IER)
- Station de Recherche Agronomique de Cinzana
- Station de Recherche Agronomique de Mopti
- Station de Koporo
- Ministère du Plan et de l'Aménagement du Territoire/ Direction Nationale des Statistiques et de l'Informatique (DNSI)
- Observatoire du Marché Agricole (OMA)

Data collected for the expected costs and benefits analysis of farm level cropping of *Bt* cowpea

Financial analysis

Private prices are the actual prices of all inputs and outputs used in production. These prices were derived from farm surveys. Prices of tradables were collected during interviews with farmers and cross-checked at the retail shops for agricultural inputs. Domestic factor prices such as labour costs, capital and land rent were collected from farm surveys and checked with extension experts.

Family labour

Farm preparation (cleaning and plowing) and crop care (weeding, botanicals preparation, establishment of pheromone traps, fertiliser application and chemical application) are generally done by the farmers themselves. The wage rate varies based on the type of work and measures per unit of area.

Hired labour

The valuation of hired labour was more complicated than family labour. All farmers hired labour in two key activities: planting and harvesting. Seed extraction and planting were generally treated as a package. Also, many farmers hired labour for cleaning, plowing and weeding. Women hired labour for chemical application. Farmers generally paid about US$ 25 to 150 per ha in Benin for field work depending on the kind of work.

Working capital

Working capital is cash used by farmers to run the cowpea farming operation and pay for the cash costs of chemicals, fertiliser and hired labour. Farmers got their working capital from various sources – capital accumulation from the previous season, borrowing from other farmers, neighbours and relatives, or borrowing from an input retailer. Other forms of lending institutions were government-supported credit and commercial credit issued by private and state banks. However, few farmers availed themselves of these two credit sources. Reasons given were the uncertainty of an agricultural business environment that could lead to an inability to pay back the loan and a lack of familiarity with the lending procedures of official financial institutions. Information on working capital was obtained from farmers who had experience in getting loans from institutions of microfinance such as Caisse Locale de Crédit Agricole Mutuel (CLCAM) in Benin. Farmers could get up to US$ 600 for 1 hectare of cowpea per year. The interest rate was around 24% per year. Based on this figure, interest for a three-month period (a production cycle) was assumed to be 6%.

Land rent

According to farmers, the average land rental rate for a cowpea field was about US$ 38 per ha per year. However, land rental in south Benin is very frequent and its cost increases fast. Indeed, access to fertile land is increasingly difficult and the use of external inputs for land saving is minimal. The very small farms are already reduced as they are divided by way of heritage. There is a strong land pressure because of the density of the high population (more than 250 habitants/km^2).

Annex III

Chart 1. Comparison between option demands for cowpea seed: Average farm household in front of the Oueme Valley agro-ecological zone in Benin

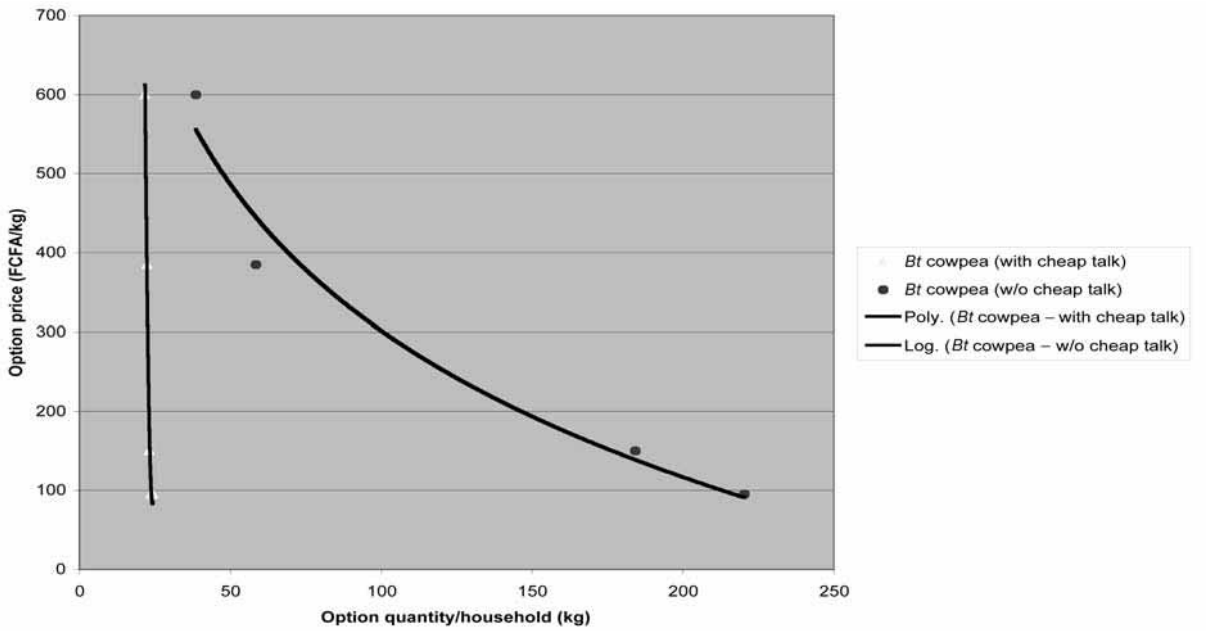


Chart 2. Comparison of option demands for *Bt* cowpea: Average farm household far from Waterway in the Oueme Valley agro-ecological zone in Benin

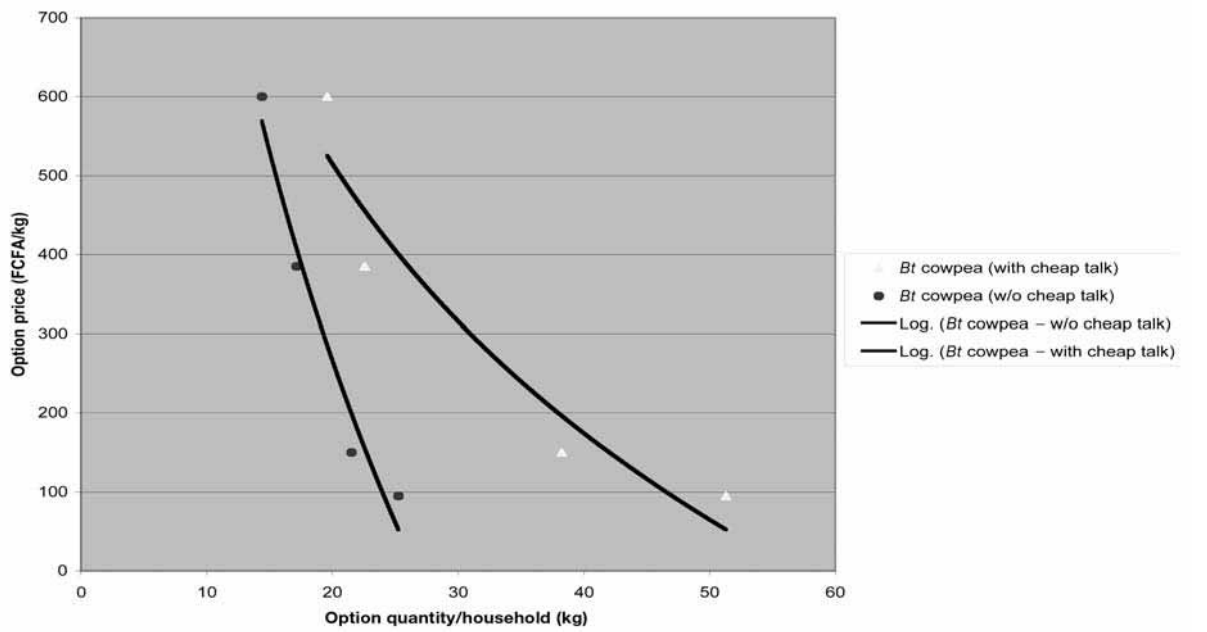


Chart 3. Option demands for conventional and *Bt* cowpea seeds by the average farm household located in front of Oueme Valley in Benin

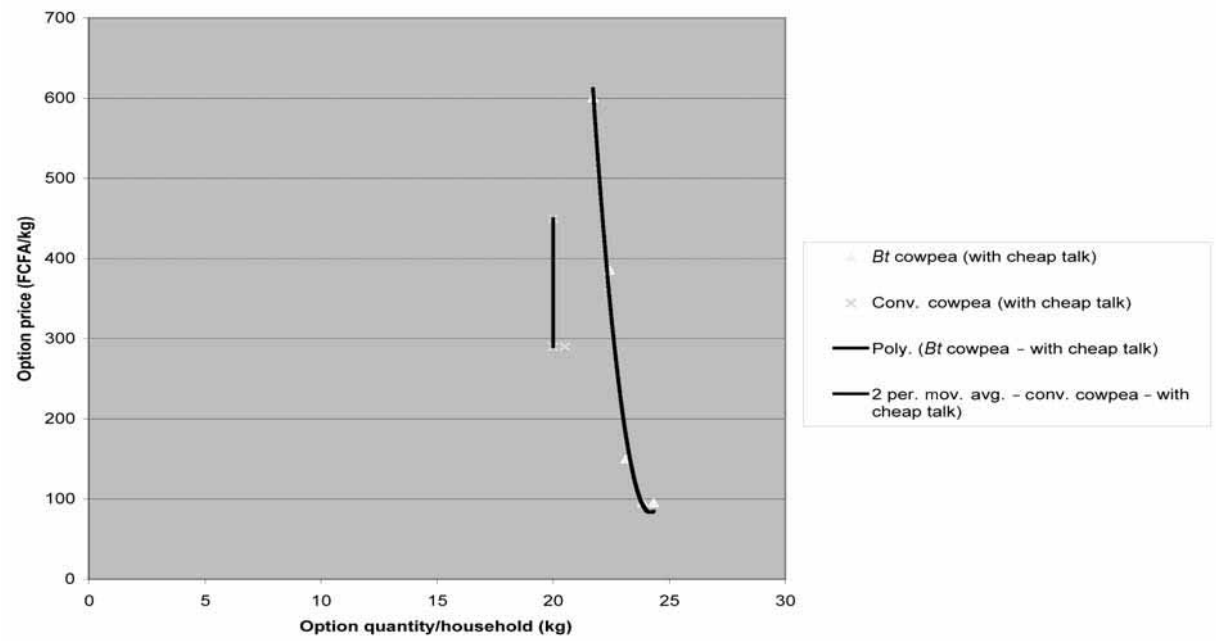


Chart 4. Option demands for conventional and *Bt* cowpea seeds by the average farm household located far from Waterway in the Oueme Valley agro-ecological zone in Benin

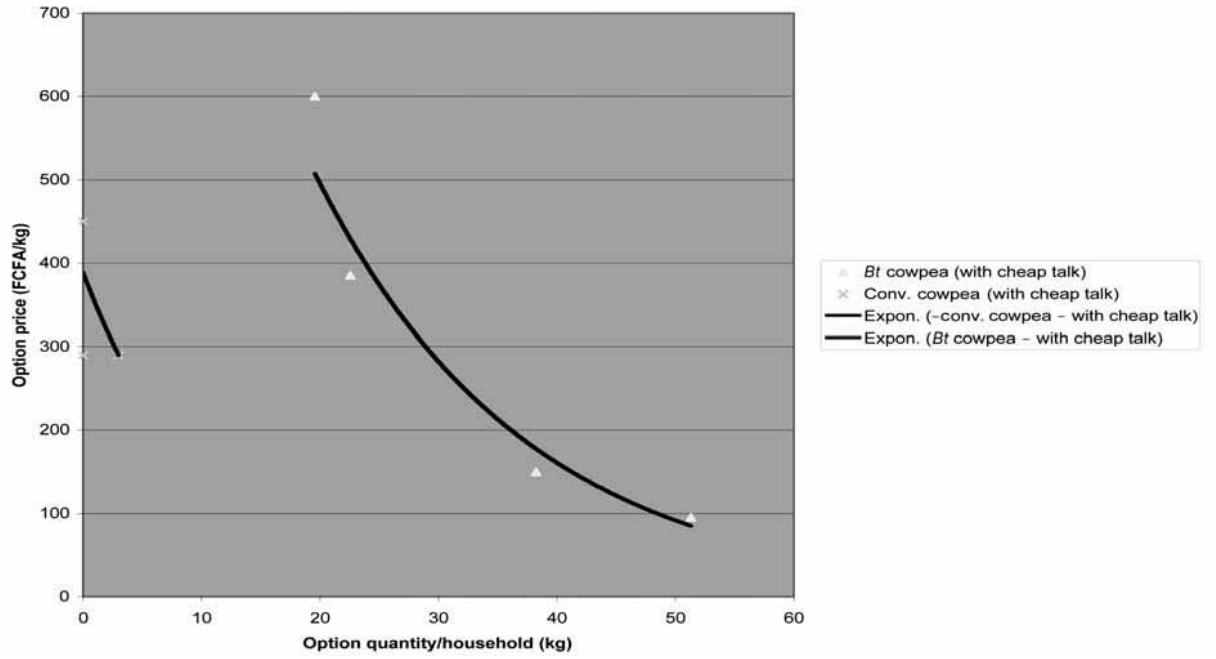


Chart 5. Economic benefits from *Bt* cowpea seed for the average farm household in the Oueme Valley agro-ecological zone in Benin

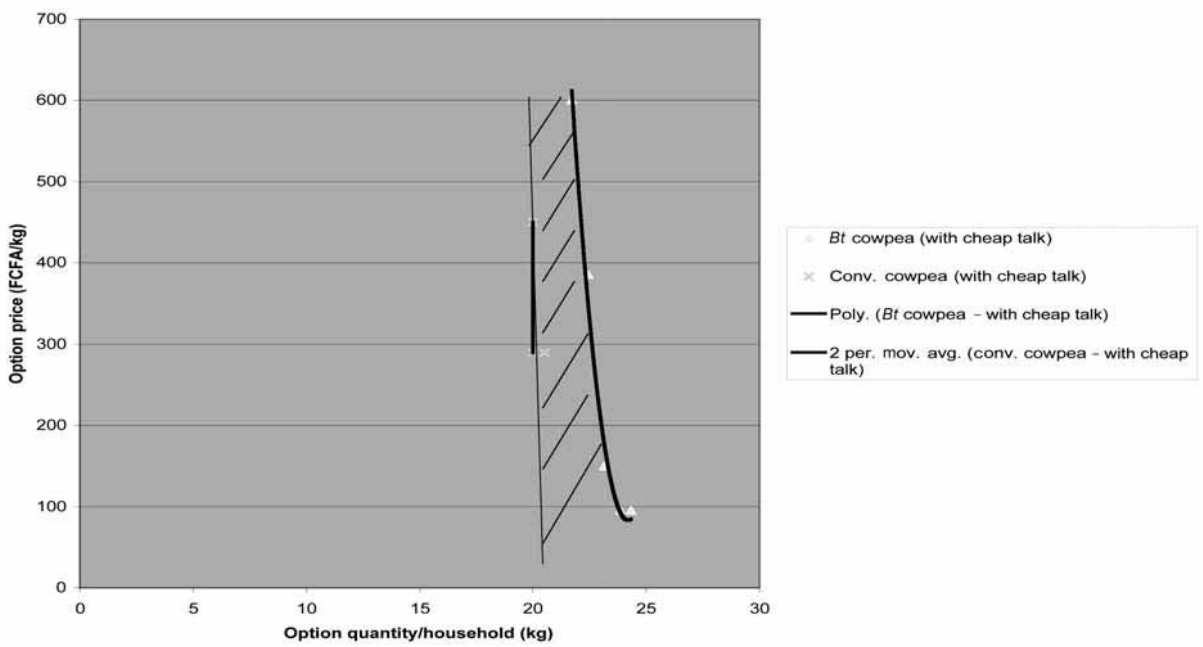


Chart 6. Economic benefits from *Bt* cowpea seed for the average farm household in the Oueme Valley in Benin

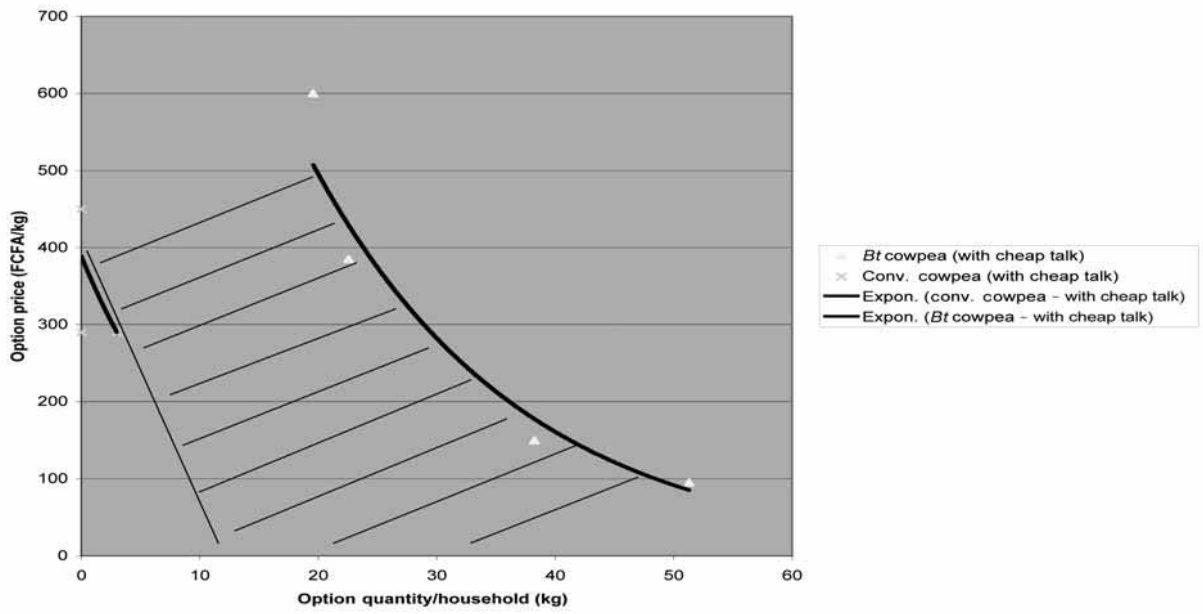


Chart 7. Option demand for *Bt* cowpea with and without cheap talk for the average urban household buying cowpea grain mainly for home consumption in Benin

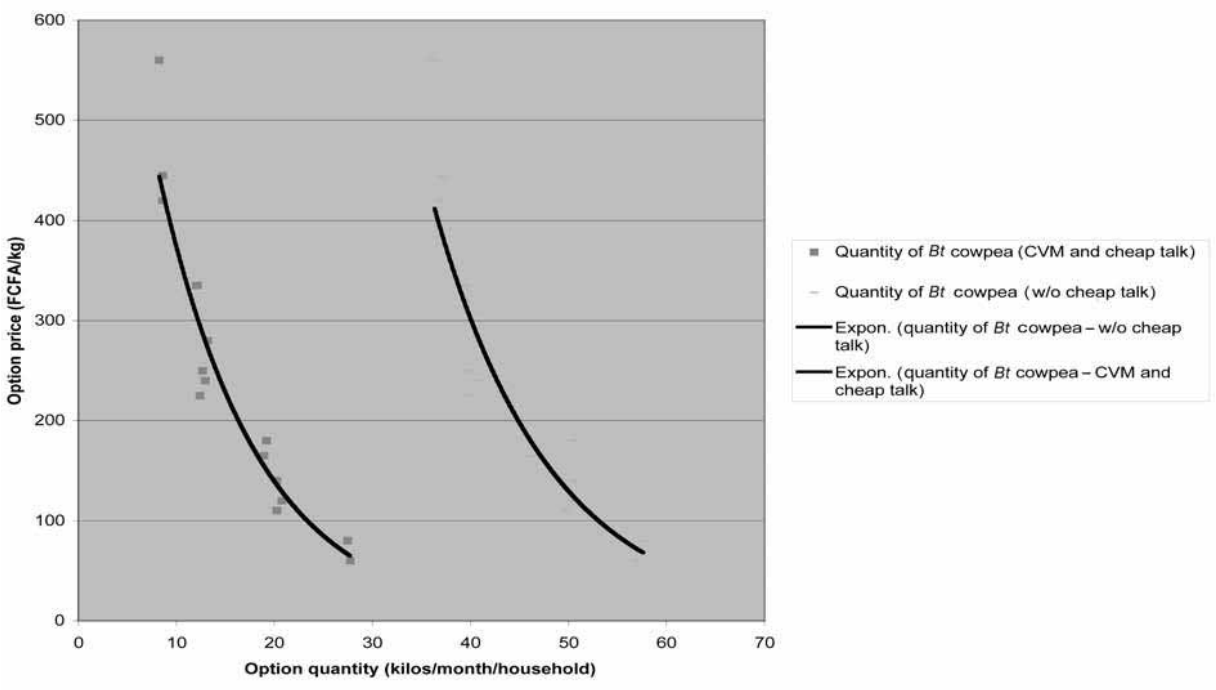


Chart 8. Option demand for *Bt* cowpea for the average urban household buying cowpea grain mainly to re-sell it in Benin

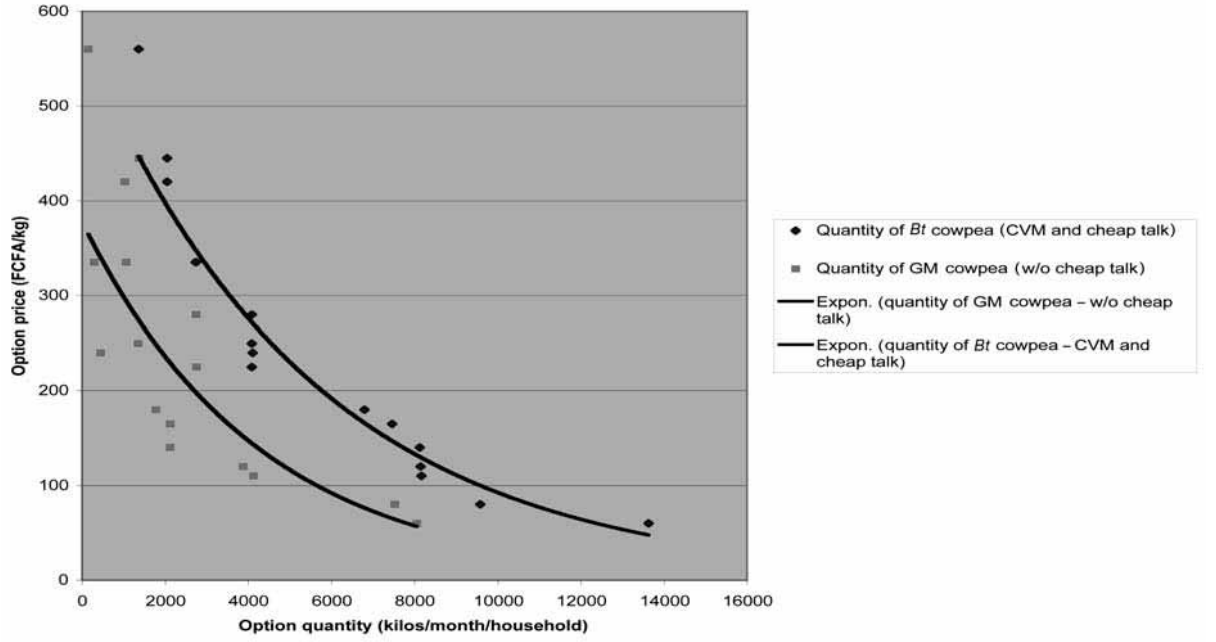


Chart 9. Economic benefits of *Bt* cowpea for the average urban household buying cowpea grain for home consumption in Benin

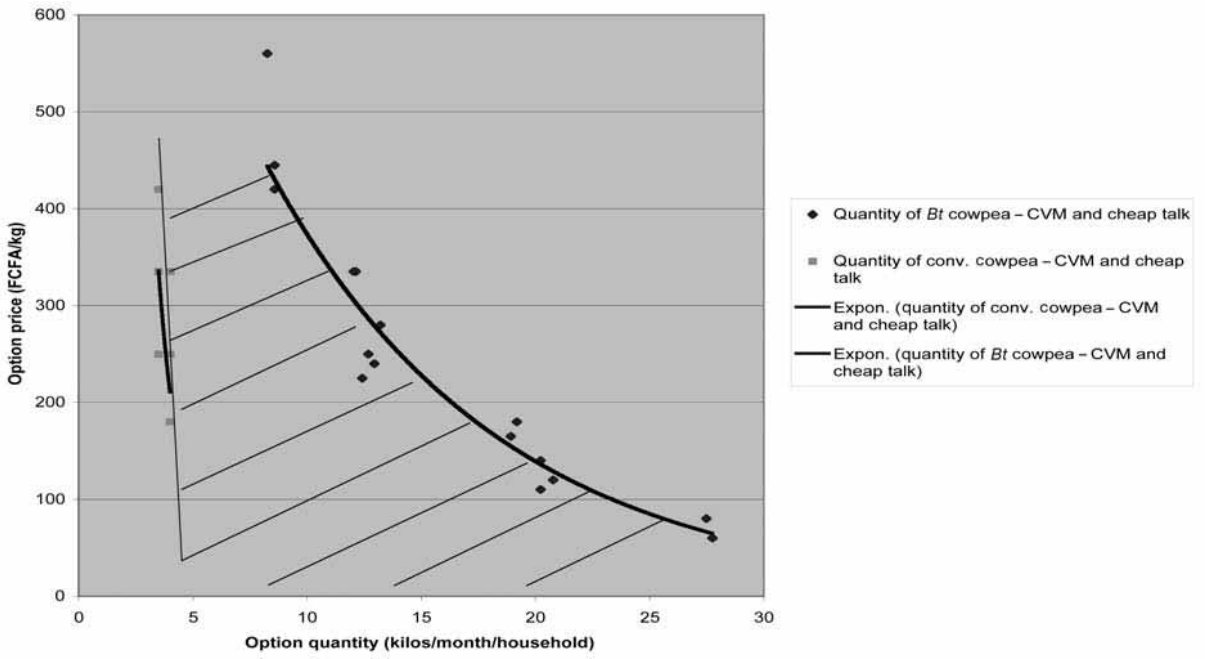
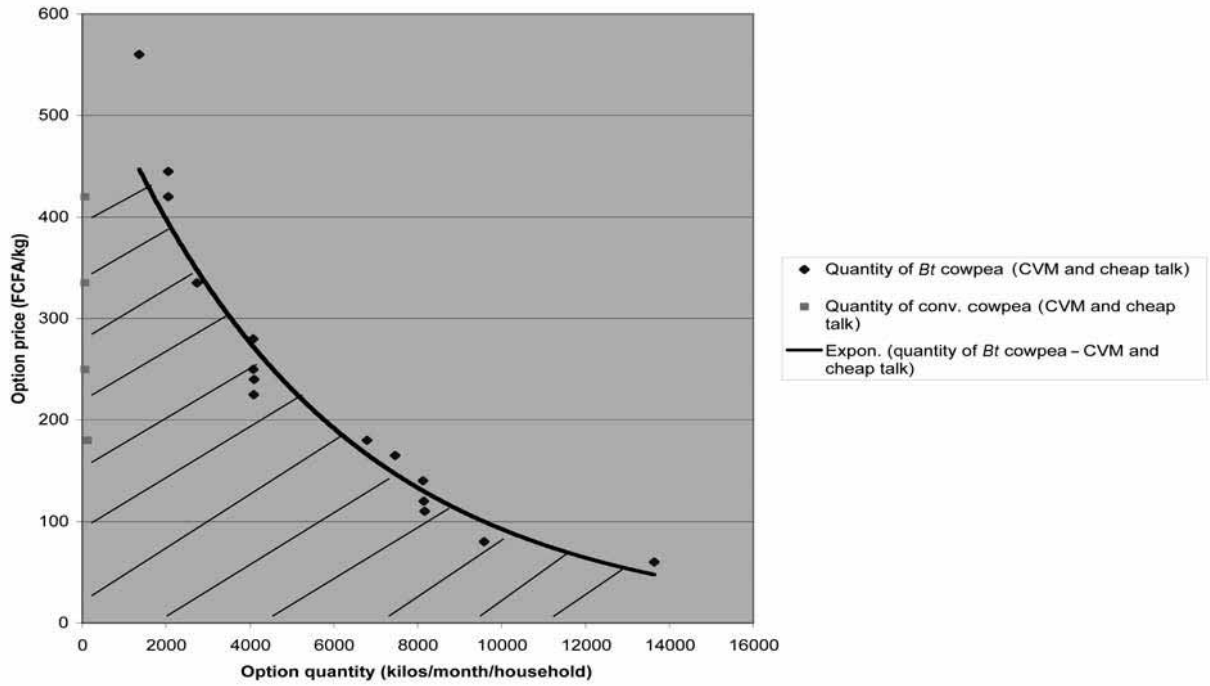


Chart 10. Economic benefits of *Bt* cowpea for the average urban household buying cowpea grain mostly for resale in Benin





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