AGRICULTURAL ECONOMICS

Agricultural Economics 48 (2017) 105–114

Cotton farmers' willingness to pay for pest management services in northern Benin

Cokou Patrice Kpadé[a,*], Edouard Roméo Mensah[b], Michel Fok[c], Jupiter Ndjeunga[b]

[a]*University of Agriculture of Kétou, Benin*
[b]*International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Niamey, Niger*
[c]*International Center of Agricultural Research for Development (CIRAD, UPR AIDA), Montpellier, France*

Received 19 May 2015; received in revised form 10 March 2015; accepted 17 March 2015

Abstract

This study was carried out to assess cotton farmers' willingness to pay (WTP) for pest management services in northern Benin. Targeted staggered control (TSC) has been introduced to reduce pesticide use in cotton cropping and generate an estimated benefit of FCFA48,800 (€74.40) per cotton hectare accruing from increased productivity and reduced pesticide cost. However, TSC application requires extra time for pest identification and scouting, and its adoption remains low due to the lack of funding to boost farmers' awareness and cover training costs. An interval regression model was used to analyze responses to a double-bounded contingent valuation survey with data collected from 300 cotton farmers. The results showed that 87.3% of cotton farmers were willing to pay for TSC services. Annual WTP per cotton hectare was estimated at FCFA16,962 (€25.80), revealing an existing demand for TSC adoption. Respondents' WTP was driven by farm and socio-economic characteristics. Financial mechanisms managed by farmers could thus potentially foster technology adoption, and in turn, generate economic and environmental benefits.

JEL classifications: O13, Q15, Q51

Keywords: Benin; Cotton farmers; Pesticides; Targeted staggered control; Willingness to pay

1. Introduction

Agriculture is now highly dependent on pesticides to control pests and diseases and boost productivity (Hashemi and Damalas, 2011; Isin and Yildirim, 2007), whereas intensive pesticide use generates negative externalities regarding farmers' health and the environment, therefore threatening farmers' future (Ntow et al., 2006; Scholl and Binder, 2009; Travisi and Nijkamp, 2008). Chemical pesticides used on farms have harmful effects on the environment, water quality, and the health of farmers and their families (Kouser and Qaim, 2011). Deaths resulting directly or indirectly from pesticide use have been reported in cotton production areas in Africa and elsewhere (Tovignan et al., 2001).

Production systems with less reliance on pesticides have been developed and promoted so as to reduce the above-mentioned negative externalities (Skevas and Lansink, 2013). Several integrated pest management (IPM) technologies have been developed for vegetable crop production, as well as for cowpea (Morse and Buhler, 1997), cotton (Matthews, 1996), and citrus production (Zalucki et al., 2009).

The so-called targeted staggered control (TSC) method is an IPM technology that was developed for cotton protection in West and Central Africa. TSC consists of six calendar-based sprays that are conducted every 14 days from 45 days after seedling emergence, with additional threshold-based sprays carried out 7 days after each calendar-based spray, but only when the threshold has been reached (Renou et al., 2012). TSC represents a tradeoff between conventional calendar control and threshold pest control (Togbé et al., 2012) and is meant to reduce pesticide use without negatively impacting yield. TSC remains calendar-based in the sense that half of the dosage recommended for calendar control is used every 2 weeks, while additional specific pesticides are sprayed only if field scouting indicates that pest infestation has exceeded the

*Corresponding author. Tel.: +229 95 95 65 69. *E-mail address:* kpadepatrice1@hotmail.com (C.P. Kpadé).

 DOI: 10.1111/agec.12298

economic threshold (Brévaut et al., 2009; Renou et al., 2012). TSC was introduced and promoted around 1994 in Cameroon, then in Benin, Mali and Togo (Brévault et al., 2009; Silvie et al., 2001). With TSC adoption, pesticide reduction is estimated at 1 L/ha of cotton in case of low infestation, corresponding to a cost savings of FCFA14,800 (€22.60) per cotton hectare as compared to the conventional calendar control method. In addition, the cotton yield gain is estimated at more than 300 kg/ha, for a value of FCFA54,000 (€82.40) (Prudent et al., 2007). At the same infestation levels on their cotton farms, financial margins derived by cotton producers are substantially higher for TSC-adopting farmers than non-TSC adopters (AIC, 2007a). With these advantages, farmers are likely to adopt TSC in Benin (Sinzogan et al., 2004; Togbé et al., 2012).

Most IPM technologies are seldom adopted despite being successful and profitable (Ntow et al., 2006; White and Wetzstein, 1995). This is the case regarding TSC in West and Central Africa, where the adoption rate is low—estimated at less than 1.0% in Cameroon, 12.0% in Benin (Silvie et al., 2013), and 29.0% in Mali (Renou et al., 2012). Recent studies on this issue in Benin revealed that specific skills and training on technology use, critical knowledge on infestation levels required for TSC application, the unavailability of specific pesticides, and the absence of TSC diffusion projects in villages are the main constraints to TSC adoption (Kpadé and Mensah, 2013). Most farmers—since they are unable to identify optimal infestation levels—may be willing to pay for technical and advisory services to apply TSC correctly.

In developing countries, it is often hard to scale up the adoption of technology, even if it has been proven effective and profitable, due to the lack of complementary investment. Innovative mechanisms to pay for services should be explored given the difficulties in gaining access to funding in developing countries. One of these mechanisms concerns reliance on financial contributions from beneficiaries (Blazy et al., 2011; Chalak et al., 2008). Contingent valuation is often used to assess respondents' willingness to pay (WTP) for goods and services that are not yet tradable in the market (Cawley, 2008; Mogas et al., 2006; Nijkamp et al., 2008; Schulz et al., 2013). Previous studies have showed that farmers in developing countries are willing to pay for agricultural services such as extension, research and educational services (Charatsari et al., 2011; Oladele, 2008; Ulimwengu and Sanyal, 2011; Yegbemey et al., 2014). In this study, we used the contingent valuation method to analyze the extent to which cotton farmers in Benin are willing to pay for technical and advisory services required for effective TSC application in order to gain benefits from lower pesticide costs and higher produce value. Based on hypothetical scenarios, we determined Benin cotton farmers' WTP and socioeconomic drivers as a way to enhance promotion of TSC and provide useful information to public and private agencies involved in the diffusion of IPM technologies.

2. Material and methods

2.1. Sampling and data collection

The survey was conducted in May–June 2008 in northern Benin (West Africa), a region where 80% of the national cotton production is concentrated. The study area consisted of 27 districts distributed across 4 counties as follows: 6 districts in Alibori county, 9 districts in Atacora county, 8 districts in Borgou county, and 4 districts in Donga county. Three pest control methods were generally practiced in this study area, namely the conventional calendar-based method involving chemical sprays every 2 weeks, the TSC method as mentioned above, and the organic production method without use of chemical pesticides. A major portion of cotton farmers implemented the conventional method and were thus targeted in the study. Three hundred farmers were interviewed in 11 districts, so the representativeness of the study was 41% of the existing districts and about 0.3% of the population of 103,027 cotton farmers in northern Benin in 2007 (AIC, 2007b). In each county, half of the districts were randomly chosen to be surveyed, but it was hard to achieve this in two counties (Borgou and Donga) as it was hard to reach farmers due to the low quality of the roads, which worsened during the survey period (rainy season). Three surveyed districts in Alibori, four districts in Atacora, three districts in Borgou and one district in Donga, were chosen according to a stratified random district-wide sampling. The district sample size was weighted by the share of non-TSC cotton area in the district over the total share of non-TSC cotton area in all retained districts. Table 1 presents the calculation and the sample size distribution by district. The sampling strategy used had the advantage of giving more weight to districts in which there was lower adoption of TSC in terms of cotton area.

Expert knowledge of local agricultural extension officers on farm size variability was taken into account to ensure the local representativeness of small, medium, and big cotton farmers[1] in each district. However, the farmers surveyed were not selected by these extension officers, but rather by three experienced enumerators, all well-trained on double-bounded contingent valuation survey procedures. The survey involved in face-to-face interviews after one focus group and three questionnaire pretests were carried out in each of the 16 districts that were not included in the actual survey in order to identify an appropriate range of bids and to validate the survey instruments. Questions included in the final questionnaire were related to cotton farmers' socioeconomic and farm characteristics, their preferences regarding environmental preservation, human health preservation, organic

[1] As a result of this approach, 50.0% of respondents had less than 5 ha, which were considered as small farms, 34.0% of respondents had between 5 and 10 ha, which were considered as medium farms, and 16.0% of respondents had more than 10 ha, which were considered as big farms. Our sample was thus dominated by small and medium farms, in line with numerous studies on cotton cultivation patterns in Benin (Gergely, 2009; Kherallah et al., 2001).

Table 1
Sample size

Northern Benin counties (population of cotton farmers†)	Districts	Total cotton area in hectares† (1)	TSC cotton area in hectares† (2)	Non-TSC cotton area in hectares† (3) = (1)-(2)	Share of non-TSC cotton area (4) = (3)/(1)	Sample weight (5) = (4)/8.35	Sample size (6) = (5)*300
Atacora (25,509)	Kérou	12,391	3,000	9,391	0.76	0.09	27
	Cobly	4,508	1,650	2,858	0.63	0.08	23
	Kouandé	3,832	2,500	1,332	0.35	0.04	13
	Pehunco	8,497	3,654	4,843	0.57	0.07	20
Donga (1,113)	Djougou	4,360	2,000	2,360	0.54	0.06	19
Alibori (63,615)	Banikoara	52,604	5,122	47,482	0.90	0.11	32
	Kandi	29,432	1,020	28,412	0.97	0.12	35
	Gogounou	16,784	1,000	15,784	0.94	0.11	34
Borgou (12,790)	Bembèrèkè	7,018	658	6,360	0.91	0.11	33
	N'dali	4,872	768	4,104	0.84	0.10	30
	Nikki	6,581	350	6,231	0.95	0.11	34
Total (103,027)		150,879	21,722	129,157	8.35	1.00	300

Note: The sampling was based on the statistics of nonadoption of TSC in the districts. The sample size of 300 farmers represented 0.3% of the 2007 population of cotton farmers in northern Benin. The county sub-samples of 83 farmers in Atacora, 19 farmers in Donga, 101 farmers in Alibori, and 97 farmers in Atacora represented 0.3%, 1.7%, 0.2%, and 0.8% of the respective county population.
†*Source*: AIC (2007b).

farming practices, reductions in pesticide use, and the contingent scenario.

As the respondents were exclusively non-TSC adopters before the survey, full information was given to all farmers regarding the institutional factors, technical and advisory service needs, yield gain advantages, pesticide savings, production cost advantages, and income improvement following TSC adoption. The TSC adoption costs, such as additional working time requirements to identify and scout pests, was also made clear to all respondents in order to facilitate their net cost-benefit analysis before making their decisions. The full description given on TSC to all farmers before starting the contingent scenario helped each respondent make reliable decisions about the technology. This was critical to avoid information bias on decision making and uncertainty among respondents and to ensure that there would not be a social desirability bias in the payment acceptance.

At the end of the survey in each district, a briefing session was conducted with the local agricultural extension agents to discuss and pinpoint any trends in the data collected and ensure their reliability. The contingent valuation scenario was carefully elaborated and pretested before the survey and data collection. Care was taken to ensure that the respondents had a full understanding of the scenario in order to facilitate their decision making and reduce bias in the WTP revelation, since it is known that an over-complex cognitive exercise during a WTP survey will lead to a lower WTP revealed by respondents (Yu et al., 2014). Across the sample, the mean farm size was estimated at around 6.7 ha and the cotton area represented 44.0% of the total farm area on average. These figures were similar to those reported in Kpadé and Mensah (2013), i.e., around 6.9 ha and 37.0% as mean farm size and degree of cotton specialization, respectively, for full-TSC adopters' farms in northern Benin. The mean age of farmers surveyed was 37 years old, and about 87.0% of them were less than 50 years old. On average, farmers had 14.1 years of cotton production experience. With regard to education[2], 44.6% of farmers were illiterate, while 53.4% of them had primary or secondary education. Agriculture was the main income source and primary activity for about 80.3% of respondents. Annual farm income was estimated at FCFA910,247 (€1,388) on average. Eleven percent of cotton farmers earned more than FCFA1.5 million (€2,288), 25.3% earned FCFA0.5 to 1.5 million (€762.70 to 2,288), while 63.7% earned less than FCFA0.5 million (€762.70). In addition to cotton, the main crops cultivated in the study zone were maize, millet, yam and sorghum.

2.2. Conceptual framework

2.2.1. WTP elicitation methods

The double-bounded contingent valuation method was used for this survey, whereby cotton farmers were asked a sequence of closed-ended questions that progressively narrowed down the WTP. The double-bounded contingent valuation approach has been shown to provide more efficient asymptotical estimates than the conventional single-bounded contingent valuation approach (Hanemann et al., 1991). The double-bounded contingent valuation approach is also generally preferred to asking open-ended questions, which is more practical in email surveys (Shi et al., 2014). Since we conducted face-to-face interviews in this survey, common "protest answers" responding with zeros or extremely high values could be given by respondents (Watson and Ryan, 2007). The procedure of the

[2] According to Kherallah et al. (2001), education levels are quite low, the average adult having just 1.4 years of schooling. School attendance is low in the north and among poor households.

Table 2
Random bid schemes used in the double-bounded contingent valuation survey

Bid schemes	Decreased follow-up bid in FCFA (if "*No*" for M_i^I)	Initial bid in FCFA (M_i^I)	Increased follow-bid in FCFA (if "*Yes*" for M_i^I)
Scheme 1	2,500	5,000	7,500
Scheme 2	5,000	7,500	10,000
Scheme 3	7,500	10,000	12,500
Scheme 4	10,000	12,500	15,000
Scheme 5	12,500	15,000	17,500
Scheme 6	15,000	17,500	20,000
Scheme 7	17,500	20,000	22,500

Source: authors (2015).

double-bounded contingent valuation approach used is described as follows.

After providing full information on TSC, respondents were asked about the payment acceptance. If respondents did not protest against the payment vehicle, then they were presented with the following survey scenario: "Considering that TSC adoption leads to a gain of more than 300 kg/ha in cotton yield, savings of at least 1 L of pesticide, reductions in pest control costs, along with environmental and human health preservation advantages, would you be willing to annually pay FCFA M_i^I per cotton hectare for technical and advisory services on TSC implementation?"M_i^I was a randomized value taken from a vector of 7 bid levels (5,000; 7,500; 10,000; 12,500; 15,000; 17,500; 20,000). The minimum and maximum bid levels were not defined arbitrarily. The minimum bid level of FCFA5,000 (€7.60) per cotton hectare represented the minimum cost for getting assistance to detect the infestation level on 1 ha in one visit during the cotton cropping season, hence the minimum cost per cotton hectare to get training, assistance, and technical advice on identifying and scouting pests during a cotton cropping season. The maximum bid level of FCFA20,000 (€30.50) per cotton hectare represented the potential cost per hectare for getting complete training and advisory assistance on TSC application during a cotton cropping season. Note that this amount was still far less than the increase in income per cotton hectare (FCFA68,800 equivalent to €105.00) that farmers could expect from TSC adoption, i.e., a cotton yield gain estimated at FCFA54,000 (€82.40) and a pesticide cost reduction estimated at FCFA14,800 (€22.60). The TSC adoption cost, measured on the basis of an additional working time required to identify and scout pests, was estimated at FCFA20,000 (€30.50) per hectare, corresponding to the maximum bid proposed to get full assistance per hectare in the contingent scenario. The net cost-benefit of TSC adoption was thus estimated at FCFA48,800 (€74.40). The first bid M_i^I was followed by a second bid, incremented (if first bid accepted) M_i^U or decremented (if first bid declined) M_i^L of FCFA2,500 (€3.80). Thus, each respondent had an initial bid M_i^I and one of the follow-up bids M_i^L and M_i^U, where $M_i^L \prec M_i^I \prec M_i^U$. Table 2 summarizes the existing schemes on this basis. There were four possible outcomes of the double-bounded contingent valuation procedure: (a) both answers were "Yes"; (b) both answers were "No"; (c) a "Yes" followed by a "No"; and (d) a "No" followed by a "Yes". We used an ex-ante approach to mitigate hypothetical bias on WTP (Loomis, 2011). During the survey, we discussed the realistic likelihood of payment with respondents by clearly explaining that the amount of bid given would actually be fully paid in the upcoming cotton cropping seasons to get the services required for TSC adoption.

2.2.2. *Econometric method*

Data from double-bounded contingent valuation surveys can be analyzed using an interval regression model in order to assess the factors driving the WTP (Cawley, 2008). Data can be organized as left-censored for No-No responses, right-censored for Yes-Yes responses, and interval-censored for No-Yes or Yes-No responses given by each cotton farmer. We assumed that each respondent i who accepted the payment vehicle had a WTP for technical and advisory services for TSC adoption equal to Y_i^* and related to the respondent's characteristics X_i according to the following equation:

$$Y_i^* = X_i\beta + \varepsilon_i, \tag{1}$$

where ε_i is assumed to have mean zero and be normally distributed.

According to Hanemann et al. (1991), we did not observe Y_i^*, but we knew that the WTP of respondent i was in the interval $[M_i^L, M_i^U]$ based on the responses given to a series of contingent valuation questions. The probability of Yes-No responses could be represented by:

$$Pr(M_i^I \prec Max\,WTP \le M_i^U), \tag{2}$$

whereas the probability of No-Yes responses was:

$$Pr(M_i^I \succ Max\,WTP \ge M_i^U). \tag{3}$$

Regarding right-censored data (Yes-Yes responses), the probability was:

$$\Pr(M_i^I \le Max\,WTP \text{ and } \mathrm{M_i^U} \le Max\,WTP) \tag{4}$$

and for left-censored data (No-No responses) was:

$$\Pr(M_i^I \succ Max\,WTP \text{ and } \mathrm{M_i^L} \succ Max\,WTP). \tag{5}$$

The maximum likelihood function was estimated through implementation of an interval regression model with STATA 11. The interval regression estimates the probability that a latent variable exceeds one threshold but is less than another threshold, i.e., it estimates the probability of the latent variable lying in a certain interval (Cawley, 2008). Finally, the interval regression model results were used to estimate the individual WTP (post-estimation prediction) and calculate both the mean and median

Table 3
Summary statistics of bids and independent variables for the WTP

Variables	Description	N	Minimum	Maximum	Mean *(SD)*	Expected Signs
Bids						
Upper bound of WTP	Upper bound level (FCFA)	110	2,500	22,500	12,500 *(5,290)*	
Lower bound of WTP	Lower bound level (FCFA)	245	2,500	22,500	12,920 *(5,137)*	
Initial bid of WTP	Bid level proposed (FCFA)	270	5,000	20,000	11,509 *(4,931)*	
Independent variables						
Age	Age of cotton farmer (years)	300	15	90	36.79 *(11.64)*	+
Income	Annual income of cotton farmer (FCFA)	300	10,000	16,000,000	910,247 *(1,927,829)*	+
Experience	Experience in cotton cultivation (years)	300	1	50	14.15 *(9.65)*	+
Total area	Total farm area (ha)	300	0.5	61	6.67 *(6.29)*	+
Percent cotton area	Cotton area*100/total farm area (%)	300	8.33	100	44.00 *(20.31)*	+
Primary school	Primary educational level of cotton farmer (0 = Not educated; 1 = Yes)	300	0	1	0.17 *(0.37)*	+
Secondary school	Secondary educational level of cotton farmer (0 = No; 1 = Yes)	300	0	1	0.37 *(0.48)*	+
Farming as main occupation	Main occupation of cotton farmer (1 = agriculture; 0 = else)	300	0	1	0.82 *(0.39)*	+
TSC awareness	Received information on TSC (1 = Yes, 0 = No)	300	0	1	0.27 *(0.45)*	+
Preference for less pesticide use	Preference for less pesticide use of (1 = Yes, 0 = No)	300	0	1	0.10 *(0.30)*	+
Preference for human health preservation	Got sick after using cotton pesticide and then had preference for human health preservation (1 = Yes, 0 = No)	300	0	1	0.70 *(0.45)*	+
Preference for organic farming practices	Preference for organic farming practices (1 = Yes, 0 = No)	300	0	1	0.90 *(0.29)*	+
Preference for environment preservation	Preference for environment preservation for future (1 = Yes, 0 = No)	300	0	1	0.78 *(0.41)*	+

Note: If the lower bound of WTP was less than FCFA2,500, it is set to a missing value. Likewise, if upper bound of WTP is over FCFA 22,500, it is set to a missing value. As 30 respondents refused the payment vehicle, 270 observations were considered in the interval regression model reported in Table 6. The mean of initial bid for the 270 respondents was FCFA11,509. Standard deviations (SD) are in brackets under the means.
Source: authors (2015).

WTPs from the sample. The summary statistics of the bids and the potential independent variables are listed in Table 3.

3. Results

Farmers' motivation was high for shifting to less intensive pesticide use. Once informed about the potential advantages of TSC adoption, nearly all respondents (95.8%) declared that they were willing to shift to a new pest control technology which helps reduce pesticide use, hence reducing harm to health and the environment. Globally, respondents were less informed on TSC but were interested in its adoption based on the claimed advantages. Eighty-five point one percent of cotton farmers had no experience in TSC adoption, while 14.9% had acquired experience on this technology through their own or other cotton farmers' practices. Only a minority of respondents (3.8%) declared that they were not interested in applying TSC, compared to 88.2% and 8.0% of cotton farmers who were respectively highly and moderately interested in TSC adoption. Preservation of human health and the environment were cited as the major motivating factors for TSC use by 87.0% and 92.0% of respondents, respectively. We found that 8.4% of respondents were not worried about to health hazards or environmental degradation due to cotton pesticide use. Preservation of biodiversity in cotton production was reported as being important by 91.2% of respondents.

3.1. Variations in bid acceptance according to the double-bounded contingent valuation survey

In the double-bounded contingent valuation survey, farmers were first asked to approve the payment vehicle before accepting or refusing the bid payment in the closed-ended questions. The bid was the monetary value that farmers would be willing to give per cotton hectare to get TSC services. Thirty respondents disapproved the payment vehicle, yielding a protest rate of 10.0% for the payment vehicle (Table 4). For these 30 respondents, we stopped the contingent scenario at this step without presenting the bid schemes. Their responses were not included in the econometric model in order to differentiate them from respondents who accepted the payment vehicle and who gave No-No responses to the bid schemes. Seventy-seven point seven percent of respondents accepted the payment vehicle and the

Table 4
Cotton farmers' responses to first bids

Bid levels (FCFA)	Acceptance responses	Refusal responses	Protest† responses	Total
5,000	49	2	10	62
7,500	26	4	2	32
10,000	53	5	9	67
12,500	27	4	1	32
15,000	33	11	3	47
17,500	18	5	2	25
20,000	27	5	3	35
Total	233	37	30	300
%	77.7	12.3	10.0	100.0

†Protest responses mean that respondents refused to pay for training and technical services on TSC adoption.
Source: authors (2015).

Table 5
Cotton farmers' responses to second bid

	Second bid		
Answer to first bid	Yes Frequency *(%)*	No Frequency *(%)*	Total Frequency *(%)*
Yes	160 *(59.3)*	73 *(27.0)*	233 *(86.3)*
No	11 *(4.0)*	26 *(9.7)*	37 *(13.7)*
Total	171 *(63.3)*	99 *(36.7)*	270 *(100.0)*

Source: authors (2015).

first bid, while 12.3% of respondents accepted the payment vehicle and refused the first bid.

The double-bounded contingent valuation approach that was used for all 270 respondents who approved the payment vehicle helped to fine tune the WTP estimation by incrementing or decrementing the bid according to responses given to the first bid. As shown in Table 5, almost 60.0% of these 270 cotton farmers accepted the double bid proposed with an increment of FCFA2,500 (€3.80), in contrast to almost 10.0% of them who refused both bids with a decrement of FCFA2,500 (€3.80). The double bid approach is effective revealing respondents' preferences in detail, because refusing the double bid does not mean that respondents have rejected the payment vehicle.

3.2. Factors affecting respondents' WTP

Table 6 shows the interval regression model results to identify factors affecting the respondents' WTP for advisory and services required for TSC adoption in Benin. Four factors significantly affected the cotton farmers' WTP (total area owned, primary level of education, percent cotton area, and preference for less pesticide use). In Table 3, the coefficient signs of three significant factors were consistent with expectations. Primary level of education, percent cotton area, and preference for less pesticide use were positively correlated with the WTP. In contrast, the total area owned was negatively correlated with the WTP. Based on the farm size and percent cotton area, our results highlighted that small farms specialized in cotton production in northern Benin were more impelled to pay for advisory and technical services for TSC adoption. Compared to illiterate farmers, cotton farmers with a primary level of education were more likely to adopt TSC, with a higher WTP, and this also applied to cotton farmers interested in reducing pesticide use in cotton cultivation. Based on post-estimation prediction related to the interval regression model, the mean and median WTP were estimated at FCFA16,962 (€25.80) and FCFA16,816 (€25.60), respectively.

4. Discussion

The double-bounded contingent valuation method was applied in this study to determine factors likely to explain the WTP for TSC services by cotton farmers in Benin. The protest rate in our survey is low compared to results often obtained in other contingent valuation studies, with the highest being 58.0% (Grappey, 1999). This confirms that face-to-face surveys reduce the protest response rate. In the Benin context, face-to-face surveys are more adapted than email, telephone or postal surveys by reducing the percentage of nonresponses. The contingent scenario is also clearly explained, which is advantageous since most respondents are illiterate. However, social desirability bias may occur when administering the questionnaire and conducting the survey (Nederhof, 1985; van de Mortel, 2008). The effects of social desirability bias were avoided in the current

Table 6
Factors affecting respondents' WTP

Independent variables	Coefficients (SE)
Income (FCFA)	−2.616E-05 *(3.47E-04)*
Age (years)	−11.955 *(79.464)*
Experience in cotton farming (years)	118.338 *(96.064)*
Education (base is Not educated):	
Primary level	5654.713*** *(2039.398)*
Secondary level	−1683.640 *(1375.283)*
Farming as main occupation (1 = yes, 0 = no)	−196.801 *(1749.030)*
Total area (ha)	−235.286** *(108.318)*
Percent cotton area (%)	70.816** *(35.340)*
TSC awareness (1 = yes, 0 = no)	2315.366 *(1584.798)*
Preferences for:	
Human health preservation (1 = yes, 0 = no)	−3508.158 *(4959.706)*
Environment preservation (1 = yes, 0 = no)	−2565.818 *(5417.724)*
Organic farming practices (1 = yes, 0 = no)	3726.570 *(3547.964)*
Less pesticide use (1 = yes, 0 = no)	5658.887*** *(1686.210)*
Constant	9837.621*** *(3293.519)*

Number of observations: 26 left-censored; 160 right-censored; 84 interval observations; sigma = 8298.536; Log likelihood = -322.059; LR $chi^2(13)$ = 35.65; Probability > chi^2 = 0.0007.
***Significant at 1%.
**Significant at 5%.
Source: authors (2015).

study by interacting in each district with local agricultural extension agents who were fully aware of the behaviors of cotton farmers, thus ensuring the validity of our results. The payment vehicle had a major role in the respondents' decision making, and special attention must be given to selection of the payment vehicle (Travisi and Nijkamp, 2008)—when the payment vehicle is not well defined, or when respondents are not accustomed to it, protest rates and hypothetical bias problems are often overestimated in the valuation survey due to heterogeneity among respondents (Diederich and Goeschl, 2014; Loomis, 2011). Although illiterate and poor, cotton farmers in northern Benin were willing to pay for services required for TSC application due to the net cost-benefit generated. Then we determined factors affecting the WTP level.

4.1. Reasons of WTP variation among cotton farmers

Farmers' WTP varies because their socioeconomic conditions are heterogeneous, as reflected in their profitability expectations, risk aversion and perceptions on adoption costs (Balzy et al., 2011; Ma et al., 2012; Shi et al., 2013). Regarding the interval regression model estimation, four factors had significant effects on the WTP for TSC adoption. The negative effect of the farm size highlighted that small-scale farmers, particularly those who were more specialized in cotton cultivation, were more likely to pay for services required for TSC adoption. Constraints to TSC application, such as the time required for pest identification, pest scouting and the knowledge required for scouting, could explain the low WTP for small-scale farmers specialized in cotton cultivation as compared to large-scale farmers (Prudent et al., 2007; Togbé et al., 2012). Small farms specialized in cotton production are more full-TSC adopters in northern Benin than big farms (Kpadé and Mensah, 2013). Moreover, when farmers had primary school education, their WTP was higher than that of illiterate farmers. This finding means that farmers with primary schooling were more convinced about the cost-benefit advantages of TSC adoption than illiterate cotton farmers. In addition, they could easily and correctly practice TSC thanks to their educational level. The preference for less pesticide use in cotton production had a significant positive effect on the WTP, probably because farmers perceived the net gains from reducing pesticide costs. In contrast, the effects of other factors on the cotton farmers' WTP for acquiring advisory and services for TSC adoption were not confirmed. Annual farm income did not significantly influence cotton farmers' WTP, probably because cotton farmers might not have reacted according to their overall wealth status, but rather to the net cost-benefit anticipated from TSC adoption on the cotton farm (Togbé et al., 2012). Although many environmental service valuation studies have found a significant effect of income on the WTP (Halkos and Jones, 2012; Loomis et al., 1997; Mogas et al., 2006), the causality was not significant in the case of TSC adoption in Benin. Cotton farmers adjust the WTP on the basis of the anticipated net cost-benefit provided by TSC adoption (Borger, 2013). The adoption of IPM technology such as TSC is thus dependent on its effectiveness in increasing net returns (White and Wetzstein, 1995).

Even though 70.0% of farmers in our sampling noted that they got sick after cotton cultivation, the preference for health preservation, environmental preservation and organic farming practices did not have significant direct effects on their WTP. Farmers in northern Benin cultivate cotton without protective equipment. The results did not confirm that they were well aware of the negative externality of the conventional cotton production method on eco-tourism services and the preservation of ecosystems and biodiversity (Azad and Ancev, 2010; Nijkamp et al., 2008; Sinden and Griffith, 2007) and on human health hazards caused by chemical sprays carried out without any protective clothing, which is consistent with patterns noted in other developing countries (Isin and Yildirim, 2007; Kouser and Qaim, 2011). If the use of chemicals to control pests is not reduced, there is little prospect that the harm to human health could be reduced through greater adoption of protective clothing, which few farmers in developing countries can afford (Cole et al., 2002; Wilson and Tisdell, 2001) and farmers are reluctant to wear such gear under tropical conditions. Pesticide-induced damage to human health and the environment could change cotton farmers' attitudes, particularly when the cost of sickness and environmental degradation are substantial and recurrent (Atreya et al., 2011).The age of cotton farmers and the number of years of cotton cultivation experience also did not significantly influence the WTP, suggesting that cotton farmers—young, old or experienced or not—behave in the same way regarding TSC adoption. Even having secondary education had a statistically insignificant effect on the WTP, contrary to the positive effect of primary education. These "relatively higher" educated cotton farmers are not impelled to have a higher WTP than illiterate cotton armers because they viewed TSC as a binding technology requiring additional working time and cost for pest identification and scouting, particularly when cultivating big farms (Ma et al., 2012). In addition, they can value their "relatively higher" education in the nonfarm sector. Contrary to farmers with a primary level of education, farmers with secondary education could assume that they are able to practice TSC without paying for extension officers (Yegbemey et al., 2014). These reasons are often reported as major constraints for TSC adoption (Prudent et al., 2007; Togbé et al., 2012). In this double-bounded contingent valuation survey, some respondents totally refused the payment vehicle, probably because they did not believe that the economic benefits from TSC would outweigh the adoption costs. Respondents' attitudes toward payment acceptance indicated that respondents could refuse the first bid and accept the second, or inversely, so the responses given by farmers in the double-bounded contingent valuation survey were thus quite well thought out, not arbitrary. When the economic benefits generated by TSC adoption were considered to be higher or lower than the adoption costs, farmers' decisions changed accordingly.

4.2. WTP estimation for large-scale adoption of TSC in Benin

The mean WTP predicted using the interval regression model fully offset the net cost-benefit resulting from TSC adoption. The market-based approach to evaluate services required for TSC application provides a valid alternative to the conventional cotton production method in Benin, and indicates how farmers could adopt new technologies with regard to variations in market scenarios (Arfini and Donati, 2013) or to cost-benefit assessment (Ma et al., 2012). The mean estimated WTP of FCFA16,962 (€25.80) was close to the FCFA14,794 (€22.50) amount that maize farmers under climate change risks in northern Benin would be willing to pay for agricultural extension services (Yegbemey et al., 2014).

Considering annual area of cotton cultivation of 350,000 ha in Benin, the mean WTP would represent a potential contribution of about FCFA5.9 billion (€9.0 million) to support widespread TSC adoption in Benin. This amount represents 12.3% of the monetary value of seedcotton sales, or 24.8% of the monetary value of inputs sales during the 2007–2008 cotton cropping season in Benin (Kpadé, 2011). This amount highly offsets the annual cost[3] needs for cotton farmers' training and extension (FCFA800 million, or €1.22 million) and for cotton research (FCFA250 million, or €381,679). Cotton farmers' commitment to paying for TSC services should not be considered incredible for the mere fact that the current study, like all studies using contingent valuation, is based on an hypothetical scenario. According to Loomis (2011), contingent valuation surveys put farmers in the position of a realistic likelihood of payment that reduces hypothetical bias on WTP, making WTP estimations some valid ex-ante studies.

From 2008 to present, the rate of TSC adoption has remained low in Benin. The constraints to TSC adoption in cotton cultivation in Benin still include training, services, advisory assistance and institutional factors (Kpadé and Mensah, 2013; Prudent et al., 2007; Silvie et al., 2001, 2013; Togbé et al., 2012). There is an existing demand for TSC adoption among cotton farmers, but no relevant public policies have been formulated to address this situation. The WTP may finance training, technical and extension services to gain knowledge on pest identification and scouting. Provision of extension and training services contributes to increasing awareness among farmers and is essential regarding the adoption or payment of new production technologies like conservation agriculture in Africa (Jaleta et al., 2013). Thus, even poor cotton farmers are willing to pay to get services required for efficient agricultural technology adoption. This finding is consistent with those of other studies on WTP regarding agricultural services (Charatsari et al., 2011; Oladele, 2008; Ulimwengu and Sanyal, 2011; Yegbemey et al., 2014).

[3] This annual cost covers the total annual cost of critical functions (training, extension services, research services, technical and advisory support, seed provision, control of input quality, development of rural roads) for cotton cultivation, which is funded yearly by the Interprofessional Cotton Association in Benin (AIC, 2006).

By using a market-based approach to address constraints to large-scale adoption of TSC, this study highlighted that the net cost-benefit generated by TSC could motivate cotton farmers to pay for services required for TSC adoption in northern Benin. Such cotton farmers' WTP represent a substantial financial amount that could be mobilized by policy makers and extension agents, gradually from a small-scale intervention on adoption to widespread mechanism to foster TSC adoption. Further research studies could include more econometric analyses using the 5-point Likert scale to measure cotton farmers' preferences regarding environmental preservation, human health preservation, organic farming practices, less pesticide use, etc., in order to assess their effects on the WTP.

5. Conclusions

Cotton remains the main traditional cash crop in Benin. Despite NGO efforts to reverse the heavy reliance of cotton production on pesticides use for controlling pests, conventional cotton production still predominates at the expense of its negative impacts on farming systems, the environment, and human health. Public policies to limit agricultural pesticide use in Benin and other developing countries are generally still weak. TSC is an alternative cotton production technology developed by agricultural research institutions to reduce pesticide use. However, the up-scaling of its adoption requires mobilizing substantial funds to address the existing technical and institutional constraints. A double-bounded contingent valuation approach was used in this study to estimate cotton farmers' WTP to get appropriate services for TSC adoption and its determinants. Most cotton farmers in northern Benin, even illiterate and poor, were found to be willing to pay for training and advisory technical services on TSC due to the net cost-benefit and environmental advantages of this technology. Their WTP for services to determine pest infestation levels and to apply correct pesticide dosages would be offset by the cotton yield gains, the reduction in pesticide use costs and the environmental and human preservation accruing from the technology. The policy implications are as follows. Farmers from developing countries, particularly from Benin, are able to perceive the advantages gained from agricultural technologies and contribute financially to remove barriers for technology adoption. In the absence or lack of public funding to disseminate efficient agricultural technologies, there can be a farmer-led financial mechanism to support services required for technology adoption. In the current case regarding cotton farming in northern Benin, farmers consent to pay annually a substantial amount per hectare that can be mobilized by extension agents to provide services and ensure wide TSC diffusion.

References

Interprofessional Cotton Association of Benin (AIC), 2006. Mission de facilitation pour la création et la mise en œuvre d'un fonds de développement de la filière coton. Rapport définitif, Cotonou.

AIC, 2007a. Etude sur la rentabilité et la pérennisation de la lutte étagée ciblée (LEC). Rapport d'étude, AIC/AFD, Cotonou.
AIC, 2007b. Official statistics on cotton production in Benin. Report of evaluation, AIC, Cotonou.
Arfini, F., Donati, M., 2013. Organic production and the capacity to respond to market signals and policies: An empirical analysis of a sample of FADN farms. Agroecol. Sust. Food 37(2), 149–171.
Atreya, K., Sitaula, B.K., Johnsen, F.H., Bajracharya, R.M., 2011. Continuing issues in the limitations of pesticide use in developing countries. J. Agric. Environ. Ethics 24, 49–62.
Azad, M.A.S, Ancev, T., 2010. Using ecological indices to measure economic and environmental performance of irrigate agriculture. Ecol. Econ. 69, 1731–1739.
Blazy, J.M., Carpentier, A., Thomas, A., 2011. The willingness to adopt agro-ecological innovations: Application of choice modeling to Caribbean banana planters. Ecol. Econ. 72, 140–150.
Borger, T., 2013. Keeping up appearances: Motivations for socially desirable responding in contingent valuation interviews. Ecol. Econ. 87, 155–165.
Brévault, T., Couston, L., Bertrand, A., Thézé, M., Nibouche, S., Vaissayre, M., 2009. Sequential pegboard to support small farmers in cotton pests control decision-making in Cameroon. Crop Prot. 28, 968–973.
Cawley, J., 2008. Contingent valuation analysis of willingness to pay to reduce childhood obesity. Econ. Hum. Biol. 6, 281–292.
Chalak, A., Balcombe, K., Bailey, A., Fraser, I., 2008. Pesticides, preference, heterogeneity and environmental taxes. J. Agr. Econ. 59(3), 537–554.
Charatsari, C., Papadaki-Klavdianou, A., Michailidis, A., 2011. Farmers as consumers of agricultural education services: Willingness to pay and spend time. J. Agric. Educ. Ext. 17(3), 253–266.
Cole, D.C., Sherwood, S., Crissman, C., Barrera, V., Espinosa, P., 2002. Pesticides and health in highland Ecuadorian potato production: Assessing impacts and developing responses. Int. J. Occup. Env. Heal. 8(3), 182–190.
Diederich, J., Goeschl, T., 2014. Willingness to pay for voluntary climate action and its determinants: Field-experimental evidence. Environ. Resour. Econ. 57(3), 405–429.
Gergely, N., 2009. The Cotton Sector of Benin. Africa Region Working Paper Series No. 125 March, 2009, World Bank, Washington D.C.
Grappey, C., 1999. Fiabilité des résultats de l'évaluation contingente et modes d'interrogation, une application à la ressource en eau souterraine. Econ. Rurale 254, 45–53.
Halkos, G., Jones, N., 2012. Modeling the effect of social factors on improving biodiversity protection. Ecol. Econ. 78, 90–99.
Hanemann, M., Loomis, J., Kanninen B., 1991. Statistical efficiency of double-bounded dichotomous choice contingent valuation. Am. J. Agric. Econ. 73(4), 1255–1263.
Hashemi, S.M., Damalas, C.A., 2011. Farmers' perceptions of pesticide efficacy: Reflections on the importance of pest management practices adoption. J. Sustain. Agric. 35, 69–85.
Isin, S., Yildirim, I., 2007. Fruit-growers' perceptions on the harmful effects of pesticides and their reflection on practices: The case of Kemalpasa, Turkey. Crop Prot. 26, 917–922.
Jaleta, M., Kassie, M., Shiferaw, B., 2013. Tradeoffs in crop residue utilization in mixed crop–livestock systems and implications for conservation agriculture. Agric. Syst. 121, 96–105.
Kherallah, M., Minot, N., Kachule, R., Soulé, B.G., Berry, Ph., 2001. Impact of agricultural market reforms on smallholder farmers in Benin and Malawi. Research report, Final report, vol. 1, IFPRI, Washington D.C.
Kouser, S., Qaim, M., 2011. Impact of Bt cotton on pesticide poisoning in smallholder agriculture: A panel data analysis. Ecol. Econ. 70, 2105–2113.
Kpadé, C.P., 2011. Adaptation de la coordination et nouvelles contradictions entre acteurs du système coton au Bénin face à la libéralisation économique. Thèse de Doctorat, Dijon, Université de Bourgogne, France.
Kpadé, C.P., Mensah, E.R., 2013. Facteurs d'adoption de la lutte étagée ciblée au Nord-Bénin. Econ. Rurale 338, 77–91.
Loomis, J., 2011. What's to know about hypothetical bias in stated preference valuation studies? J. Econ. Surv. 25(2), 363–370.
Loomis, J., Brown, T., Lucero, B., Peterson, G., 1997. Evaluating the validity of the dichtomous choice question format in contingent valuation. Environ. Resour. Econ. 10, 109–123.
Ma, S., Swinton, S.M., Lupi, F., Jolejole-Foreman, C., 2012. Farmers'willingness to participate in payment-for-environmental-services programmes. J. Agric. Econ. 63(3), 604–626.
Matthews, G.A., 1996. The importance of scouting in cotton IPM. Crop Prot. 15, 369–374.
Mogas, J., Riera, P., Bennett, J., 2006. A comparison of contingent valuation and choice modeling with second-order interactions. J. For. Econ. 12, 5–30.
Morse, S., Buhler, W., 1997. IPM in developing countries: The danger of an ideal. Integrated Pest. Manag. Rev. 2, 175–185.
Nederhof, A.J., 1985. Methods of coping with social desirability bias: A review. Eur. J. Soc. Psychol. 15, 263–280.
Nijkamp, P., Vindigni, G., Nunes, P.L.D., 2008. Economic valuation of biodiversity: A comparative study. Ecol. Econ. 67, 217–231.
Ntow, W.J., Gijzen, H.J., Kelderman, P., Drechsel, P., 2006. Farmer perceptions and pesticide use practices in vegetable production in Ghana. Pest Manag. Sci. 62, 356–365.
Oladele, O.I., 2008. Factors determining farmers' willingness to pay for extension services in Oyo State, Nigeria. Agric. Tropic. Subtropic. 41(4), 165–170.
Prudent, P., Loko, S., Deybe, D., Vaissayre, M., 2007. Factors limiting the adoption of IPM practices by cotton farmers in Benin: A participatory approach. Exp. Agric. 43, 113–124.
Renou, A., Togola, M., Téréta, I., Brévault, T., 2012. First steps towards "green" cotton in Mali. Outlook Pest Manage. 23(4), 173–176.
Scholl, R., Binder, C., 2009. Comparing system visions of farmers and experts. Futures 41, 631–649.
Schulz, N., Breustedt, G., Latacz-Lohmann, U., 2013. Assessing farmers' willingness to accept "greening": Insights from a discrete choice experiment in Germany. J. Agr. Econ. 65(1), 26–48.
Shi, L., Gao, Z., Chen, X., 2014. The cross-price effect on willingness-to-pay estimates in open-ended contingent valuation. Food Pol. 46, 13–21.
Shi, L., House, L.A., Gao, Z., 2013. Impact of purchase intentions on full and partial bids in BDM auctions: Willingness-to-pay for organic and local blueberries. J. Agr. Econ. 64, 707–718.
Silvie, P., Deguine, J.P., Nibouche, S., Michel, B., Vaissayre, M., 2001. Potential of threshold-based interventions for cotton pest control by small farmers in West Africa. Crop Prot. 20, 297–301.
Silvie, P.J., Renou, A., Vodounnon, S., Bonni, G., Adegnika, M.O., Héma, O., Prudent, P., Sorèze, J., Ochou, G., Togola, M., Badiane, D., Ndour, A., Akantetou, P.K., Ayeva, B., Brévault, T., 2013. Threshold-based interventions for cotton pest control in West Africa: What's up 10 years later? Crop Prot. 43, 157–165.
Sinden, J.A., Griffith, G., 2007. Combing economic and ecological arguments to value the environment gains from 35 weeds in Australia. Ecol. Econ. 61, 396–408.
Sinzogan, A.A.C., Van Huis, A., Kossou, D.K., Jiggins, J., Vodouhè, S.D., 2004. Farmers' knowledge and perception of cotton pests and pest control practices in Benin: Results of a diagnostic study. NJAS 52(3-4), 285–303.
Skevas, T., Lansink, A.O., 2013. Reducing pesticide use and pesticide impact by productivity growth: The case of Dutch arable farming. J. Agr. Econ. 65(1), 191–211.
Togbé, C.E., Zannou, E.T., Vodouhè, S.D., Haagsma, R., Gbèhounou, G., Kossou, D.K., van Huis, A., 2012. Technical and institutional constraints of a cotton pest management strategy in Benin. NJAS 110, 1–12.
Tovignan, S., Vodouhè, S., Dinham, B., 2001. Cotton pesticides cause more deaths in Benin. Pestic. News 52, 12–14.

Travisi, C.M., Nijkamp, P., 2008. Valuing environmental and health risk in agriculture: A choice experiment approach to pesticides in Italy. Ecol. Econ. 67, 598–607.

Ulimwengu, J., Sanyal, P., 2011. Joint Estimation of Farmers' Stated Willingness to Pay for Agricultural Services. IFPRI Discussion Paper 01070, March 2011, Washington D.C.

van de Mortel, T.F., 2008. Faking it: Social desirability response bias in self-report research. Aust. J. Adv. Nurs. 25(4), 40–48.

Watson, V., Ryan, M., 2007. Exploring preference anomalies in double bounded contingent valuation. J. Health Econ. 26, 463–482.

White, C.F., Wetzstein, M.E., 1995. Market effects of cotton integrated pest management. Am. J. Agric. Econ. 77, 602–612.

Wilson, C., Tisdell, C., 2001. Why farmers continue to use pesticides despite environmental, health and sustainability costs. Ecol. Econ. 39, 449–462.

Yegbemey, R.N., Yabi, J.A., Heubach, K., Bauer, S., Nuppenau, E.A., 2014. Willingness to be informed and to pay for agricultural extension services in times of climate change: The case of maize farming in northern Benin, West Africa. Clim. Dev. 6(2), 132–143.

Yu, X., Yan, B., Gao, Z., 2014. Can willingness-to-pay values be manipulated? Evidence from an organic food experiment in China. Agric. Econ. 45(S1), 119–127.

Zalucki, M.P., Adamson, D., Furlong, M.J., 2009. The future of IPM: Whither or wither? Aust. J. Entomol. 48, 85–96.

Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Appendix.
Results of econometric model using STATA