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A LATENT CLASS APPROACH TO FARMERS' PREFERENCE FOR PONA SEED YAM CERTIFICATION SYSTEM IN GHANA

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ABSTRACT: *The study employed choice experiment methods and latent class model to assess farmers' preferences for seed yam certification system and their willingness to pay for certified seed yam in Kintamop, East Gonja and Afram Plains Districts in Ghana. A total of 9120 choice experiments were elicited from 380 yam farmers. The study identified three classes/ market segments of farmers regarding preferences for Pona seed yam. The results show that farmers have more utility towards fully certified seed yam and are willing to pay ¢719.6 for a bunch of fully certified seed yam. The findings indicate that the likelihood that a randomly chosen farmer would prefer fully certified seed yam was 88.9%. Farmers have high utility towards medium sized seed yam for Pona variety and were willing to pay ¢12.5 for this attribute. The results demonstrate market potential for commercial seed yam certification system in Ghana.*

KEYWORDS: Choice Experiment, Seed Yam, Market Segmentation, Willingness to Pay

INTRODUCTION

Yam is one of the roots and tuber crops that provide food for millions of people in West Africa. Yam production also offers employment and income to millions of value chain actor in the subregion (Boadu et al., 2018; Mignouna et al., 2014; Maroya et al., 3013; Otoo et al., 2013; MEDA, 2011; Babaleye, 2003). Among the six common yam species found in West Africa, D. rutundata (white yam) is widely produced for consumption and income (Boadu et al, 2018; Aidoo, 2009; Markson et al., 2010; Otegbayo et al., 2001). The Pona yam variety (which belongs to the D.rotundata species) is the most preferred because it is early maturing; has good taste and commands higher prices on both local and international markets (Okorley and Addai, 2010; Otoo et al.,2009; Aidoo, 2009; Boadu et al., 2018) found that Pona yam variety dominated farmers' production in all the major yam producing districts in Ghana.

Yam production is mainly constrained by unavailability of quality seeds. The situation is compounded by unstructured market for seed yam resulting in high cost of seed yam (Aighewi and Maroya, 2013; Otoo et al., 2013; MEDA, 2011). Morris et al. (1999) posits that improved seeds is the main inputs that affects productivity compared to all other inputs in

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agricultural production. Advancement in agricultural research has led to the development of improved varieties to help overcome seed quality constraints and availability to enhance agricultural productivity especially in the grains and legume subsect. The yam subsector in not an exception, seed yam which is the major constraints to production has received greater attention in the last decades (Maroya et al., 2014). These efforts are aimed at making quality seed yam available at affordable prices to reduce production costs, enhance productivity and thereby reduce the price paid by consumers (Otoo et al, 2013). The efforts have resulted in development of seed yam production techniques including minisett techniques, vine cutting, tissue culture, aeroponics and hydroponics (Maroya et al., 2014). Despite these developments, adoption by farmers remains low (Aighewi et al, 2014; Otoo et al., 2013; MiDA 2010). To address the seed yam challenge, efforts are geared towards the establishment of seed yam certification system to produce and supply quality seed yam to farmers at affordable prices to farmers at planting seasons (IITA, 2014; MEDA, 2011; MiDA, 2010). A policy in this direction should be based on a detailed understanding of the value farmers attach to seed yam attributes, their preference for seed yam certification system, and market characteristics of seed yam. This paper employs branded choice experiment to assess: (i) farmers preferences for Pona seed yam certification system; (ii) existence of seed yam market segmentation that may require different marketing strategy; and (iii) farmers' willingness to pay for certified seed yam.

CONCEPTUAL FRAMEWORK

The discrete choice models for choice of seed yam certification/supply system and segmentation was developed based on path diagram of McFadden (1986) and Swait (1994). Figure 1 shows the farmer's choice framework. The primary focus of this framework is to identify the underlying factors that influence an individual farmer's or group choice for seed yam certification system. Given that seed certification system is a discrete choice commodity with varying traits and potentials to meet several objectives, the farmers'/decision maker's problem is the choice of seed yam certification system that best maximizes his/her utility obtained from preferred traits from a choice set of alternative profiles with different levels of traits. These profiles can be viewed as representing different characteristics of seed yam as pertained to different seed certification systems.

The farmer/decision maker is faced with the choice of three main alternatives of seed certification systems. They are the informal/traditional system (zero percent or no certification), semi-formal/quality declared system (10 percent certification) and formal/quality seed system (100 percent certification) (FAO, 2006).

The factors in the rectangles represent the choice variables the researcher is able to observe and the variables in the ellipses are unobservable by the researcher. All these factors influence the utility farmers derive from the choice of a particular seed yam certification system. General attitudes and perceptions influence the probability of an individual farmer belonging to a specific farmer class/segment.

The heterogeneous farmer classes are assumed to be formed, among others, based on farmers' differing attitudes towards, and perceptions of seed yam. For instance, their perception about the quality of seed yam they are currently using for yam production could determine the class/segment they belong. These general attitudes and perceptions are

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reproduced for the researcher by the perceptual and attitudinal indicators that work as proxy variables for the actual attitudes. In this study, the respondents stated their seed yam purchasing habits and attitudes, and seed yam attributes preference for different seed yam certification systems.

The socio-demographic background of the individual such as age, educational level, income, and experience in yam production are likewise assumed to have an impact on the probability that a farner belongs to a given class. This membership likelihood function provides the foundation for the formation of heterogeneous farmer classes. It expresses the probability of an individual farmer belonging to a specific class. In Figure 1, this process is illustrated by the mechanism where the latent class selection of the farmer is determined through the membership likelihood function which aid latent class selection of farmers/decision makers into latent classes (Swait, 1993).

The farmer's latent class and socio-demographic characteristics affect his/her seed certification attribute preferences, which are likewise unobservable to the researcher. The attributes may be perceived differently by different farmers, and these dissimilarities in the perception of the seed yam attributes would have an impact on their choice. The decision protocol involves scrutinizing the subjective preferences, resulting in the individual's observable choice behavior-that is the choice of an alternative in the choice set. Obviously, the market conditions and constraints also impact on the individual's choice behaviour, as for instance his choice set is restricted by the products available and access to effective market. The socio-demographic and attitudinal information on the farmers are used only posterior to the statistical analysis in order to describe the heterogeneous farmer classes, although their latent attitudes and perceptions prevail in their stated choice behavior, in line with this framework.

The choice process framework demonstrates the importance of accounting for heterogeneity in farmer preference studies and for that matter willingness to pay studies, which is a strong tendency in recent research. A major difference within the approaches incorporating heterogeneity is their position towards the source of heterogeneous preferences. Some statistical models require farmers to be grouped based on prior assumptions of the reasons for their heterogeneity, for instance nationality or age, whereas others allow for the source to be determined during the analysis, based on the choices made by the consumers. The condition to predetermine the nature of the heterogeneity is very restrictive, as researchers do not always have sufficient knowledge on the matter (Boxall and Adamowics, 2002). Therefore, in this study the existence of heterogeneity was determined statistically during estimation. Birol et al., (2012) present a summary of the number of models developed to address heterogeneity. Latent Class Model is used to identify the sources of heterogeneity at segment level in this study.

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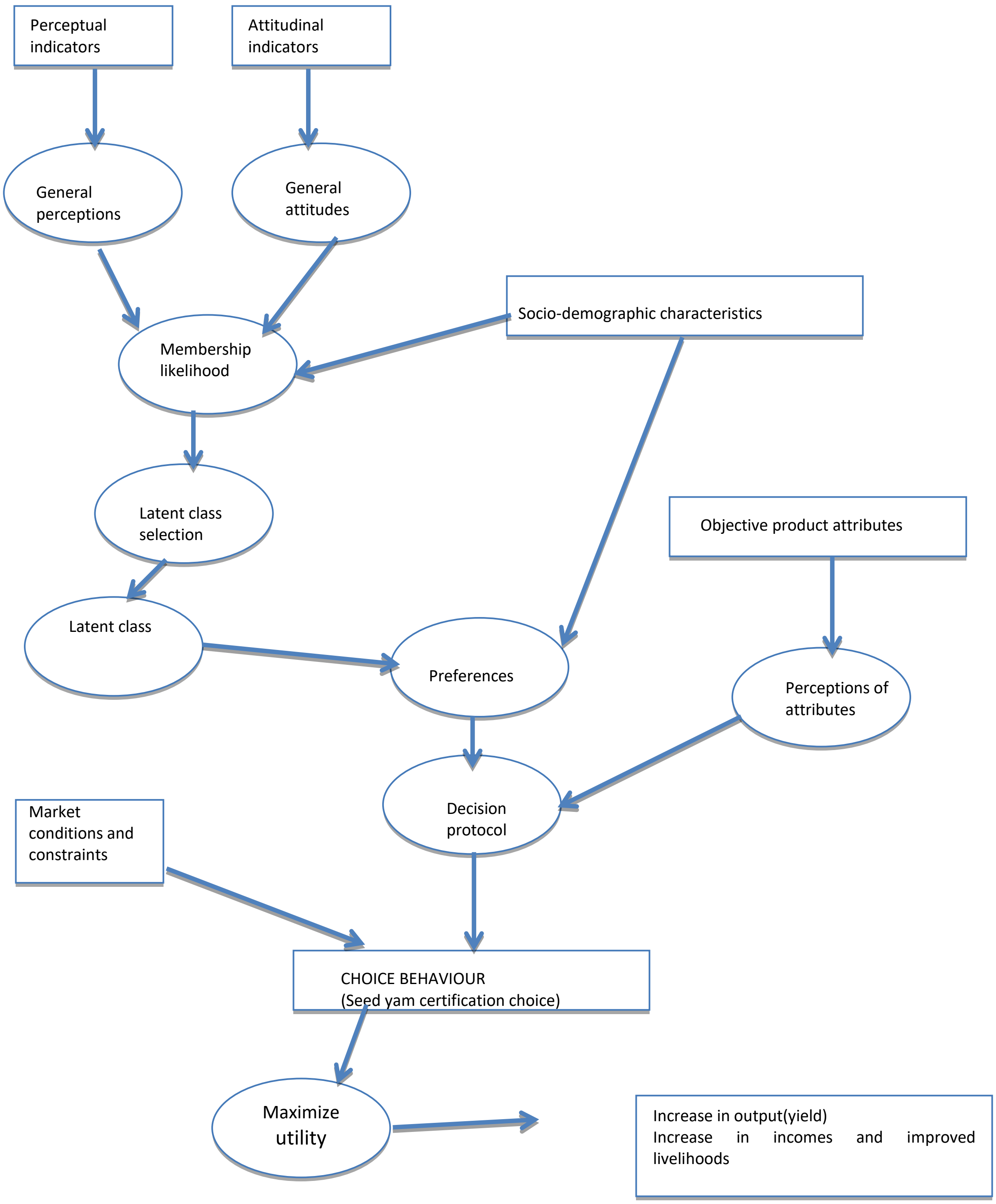

Figure 1: Choice modelling framework for consumer choice and latent class membership

Source: Adopted from Swait (1994)

The economic model for the discrete choice framework for seed certification system shown

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in Figure 1 considers unobserved heterogeneity. Each farmer's/individual's choice set C_n, is assumed to have a finite set of "*J*" mutually exclusive and exhaustive alternative seed yam attributes to choose from in each choice set of seed yam certification systems. In each of the choice situations, a sampled decision maker is assumed to have full knowledge of the factors that influence his/her choice decision when asked to choose the most preferred seed yam profile from the competing "*J*" alternatives subject to budget constraint.

Following the random utility theory, an individual *n* receives utility *U* from choosing an alternative equal to $U_{njt} = U(X_{njt})$ from a finite set *j* alternatives in a choice set, if and only if this alternative generates at least as much utility as any other alternative, with X_{njt} denoting a vector of the attributes of *j*. According to Random Utility Theory, the utility of a good is composed of an observable or deterministic component, which is a function of a vector of attributes; and an unobservable or random error component (Boxall and Macnab, 2000). The following equation for an individual's utility formalizes the basic relationship where (V_{njt}) is the observable component and (ε_{njt}) represents the error component of utility.

$$u_{njt} = V_{njt} + \varepsilon_{njt} \qquad (1)$$

The equation (2) disaggregates the systematic component of choice further, where respondent (*n*) derives utility (U_{njt}) from the alternatives (*j*) in choice set (*C*); utility is held to be a function of the attributes of the good (z_{njt}) and the characteristics of the individual (S_n), together with the error term.

$$U_{njt} = V(z_{njt}, s_n) + \varepsilon_{njt} \qquad (2)$$

Due to the inherent stochastic or random error component of (U_{njt}), a researcher can never hope to fully understand and predict preferences, hence, choices made between alternatives are expressed as a function of the probability that respondent (*n*) will choose (*j*) in preference to other alternatives if and only if $u_{njt} > u_{njh}$. Based on this, the probability that the n^{th} individual chooses the j^{th} alternative can be expressed as: $P_{nji} = p(u_{nji} > u_{njh}), \forall\, i \neq j$ (3)

From (3) we can derive (4)

$$P_{nji} = p\,(u_{nji} + \varepsilon_{nji} > u_{njh} + \varepsilon_{njh}) \qquad \forall\, i \neq j \qquad (4)$$

And:

$$P_{nji} = p\,(+\,\varepsilon_{nji} - \varepsilon_{njh} > u_{nji} - u_{njh}) \qquad \forall\, i \neq j \qquad (5)$$

Equation (5) is a cumulative distribution, meaning the probability that each random term is below the observed quantity (Train, 2003).

A number of models has been employed to empirically estimate choices made by farmers from choice experiment data and account for heterogeneity in taste and preference among farmers. The choice of model is usually based on the assumption of choice preference across respondents. They include Conditional logit Models which assumes preference homogeneity (Acheampong, 2015; Koistinen, 2010; Asrat *et al*., 2009; Train, 2003; Ouma *et al*., 2004; Bateman *et al*., 2002); Missed Logit Models which assumes preference heterogeneity but fails to explain the sources of heterogeniety (Hole, 2013; Asrat *et al*., 2010; Hole, 2008; Asrat *et al*., 2009; Greene *et al*., 2006; Ouma *et al*., 2007; Greene, 2003; Adamowicz, 2002; Train, 1998); and Latent Class Models which assumes preference heterogeneity and accounts for the sources of heterogeniety (Birol *et al*., 2012; Pouta *et al*., 2010; Hu *et al*., 2004; Vermunt and Magidson, 2005); Boxall and Adamowicz, 2002; Louviere *et al*., 2000; Green and Hensher, 2003; McFadden and Train, 2000; Swait, 1994). Latent Class model is applied in this study to account for heterogeneity of preference among yam farmers and also explain the sources of such variations.

METHODOLOGY

Study area

The study was carried out in three main yam farming districts in Ghana – Kintamp municipality in the Brong Ahafo region, East Gonja district in the Northern region, and Kwahu North (Afram plains) district in the Eastern region of Ghana. These districts were selected purposively based on their location in the major yam producing regions in Ghana as well as their agro-ecological distributions. Also, the selected districts have benefited from other government and donor-funded support projects that have established demonstration farms to showcase the benefits of quality seed yam to farmers.

Sampling

The Ministry of Food and Agriculture Directorate of the selected District Assemblies were consulted for the list of major yams producing communities. The lists formed the sampling frame. Simple random sampling was used to select five (5) communities in each district. At the community level, listing of houses and households was conducted to provide a sampling frame of yam farmers. With the aid of the sampling frame, simple random sampling was used to select at least twenty-seven (27) yam farmers per community for the study. Large peri urban communities such as Maame Krobo were imaginary divided into four (4) parts. Simple random sampling was then used to choose one of the four parts before listing of houses and households was done to obtain the sampling frame. A total of three hundred and Eighty (380)[1] yam farmers responded to the questionnaire

Survey design and implementation

Sequential mixed methods were used in this study (Creswell, 2012). The qualitative survey involving key informant interviews and focus group discussions (separate for males and female) were conducted in the study locations. The discussions helped to gain an

[1] The listing of 15 communities resulted in a total population of 908 yam farmers (ranging from 21 to 110 yam farmers per community). Sample size calculator was used to determine that appropriate sample size (http://www.raosoft.com/samplesize.html). Given a population of 908 yam farmers, 5% margin of error, and 50% response distribution, a minimum sample of 271 yam farmers is required to make inferences at 95% confidence level.

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understanding of differences in values, opinions, behaviours, and social contexts of yam producers. The selection of traits or attributes used in the choice experiment was guided by characteristics that are expected to affect farmers' choices, as well as those that are policy relevant. The quantitative survey that followed involved administration of the structured questionnaires to the selected respondents. The questionnaire captured information on personal and household characteristics, farming information including their perception about the availability, quality, yield and storage characteristics of white yam varieties cultivated. It also included branded choice sets to elicit farmers' preferences for certified seed yam attributes for Pona.

The choice experiment employed the actual seed certification system names as choice options, hence labeled or branded choices, with three alternative choices (informal, semi-formal and formal seed certification system). Branded alternatives were employed because it provided a good context to present different traits of seed yam of a given variety to farmers as pertained in alternative seed certification system. Furthermore, the white yam varieties for which seed yams are scarcely available are well known to yam farmers, as such using generic alternatives would not be considered realistic by yam farmers. For instance, Pona variety is well known to be the premium variety, which is early maturing, good taste and commands high market demand, both local and international.

Accordingly, the alternatives were described in terms of seed yam attributes as related to a given seed certification system and a monetary price to be paid for the attributes by the respondents. By analyzing the choices made by the respondents, it is possible to infer the trade-offs that farmers make between values attached to seed yam certification attributes presented to them. This in turn allows the estimation of changes of private benefits with changing levels of seed yam certification attributes. Furthermore, by incorporating heterogeneity into the analysis helps to examine welfare measures of some hypothetical policy change and provides insight into the different impact of alternative policies (Birol *et al*., 2012; Alpizar *et al*., 2003).

A combination of information obtained through interview with crop breeders, focus group discussion with yam farmers and traders, experienced researchers and literature aided identification and selection of attributes of seed yam for the choice experiment design. Each alternative in a given choice set is defined by attributes with varying levels (Burton *et al*., 2001). In this study, choice sets with alternative attributes of seed yam were presented to farmers. The seed yam certification attributes, and their defined levels are explained below:

Yield potential: This is the total output per unit area. This is very important to farmers. Yield potentials of seed yam is included in the design to see how it influences farmers' preference and willingness to pay. Given the fact that farmers depend on output for their yearly incomes and food requirements, it is expected that yield potentials of seed yam will have positive impact on farmers' preference for certified seed yam and their willingness to pay. The high yield potentials of quality seed yam are expected to induce farmers to purchase and use certified seed yam since farmers are rational and motivated by expected output and hence profit in their production activities (Assa *et al*., 2014).

Yield potential is measured as continuous variable. In the choice experiment, yield potential

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was defined in three levels: (1) 6-18t/ha ≈12t/ha[2]; (2) 16-25t/ha ≈20.5t/ha; and (3) 26-70t/ha≈48t/ha[3]. The yield levels correspond with informal, semi-formal/quality declared and formal/quality seed system, respectively, in the choice experiment. The productivity levels were set based on farmers' current yields and yields from research managed fields. The values of the actual productivity levels were computed from production level data and yield data of improved seed yam from the Crops Research Institute (CRI) of Ghana.

Percentage certification: Seed certification was included in the design because it has the potential to provide farmers with a greater level of guarantee that the seed yam is disease-free. It is expected that this will have positive influence on farmers' preference for seed yam and willingness to pay. This is measured as a dummy variable. The percentage certification was measured in three levels in the choice experiment based on FAO(2006): (1) 0% certification for informal seed system, (2) 10% certification during production and then 10% when ready for market for semi-formal seed system, and (3) 100% certification for formal/quality declared seed system.

Disease infestation: In the wake of climate change and frequent environmental variations, farmers are expected to be concerned about environmental adaptability in terms of the ability of improved variety to resist disease infestation. It is therefore expected that certified seed yam would have minimum to low infestation. This will have a positive effect on farmers' preference for quality seed yam and willingness to pay. Disease infestation was measured at three levels in this choice experiment based on the probability of the seed being infested: (1) high level infestation in the case of informal seed system (>60 %); (2) Medium level in the case of semi-formal/quality declared seed system (10-60%); and (3) Low level in the case of formal/quality seed system (<10%).

Seed size: The size of seed yam tuber is included in the model because it has the potential of influencing farmers' preference for seed yam and their willingness to pay. The sizes of seed yam planted by farmers are determined by their expectation of the output and the targeted market. Also, farmers are able to obtain higher ratio about 1:6 planting sets from larger seed size compared to other sizes. It is anticipated that seed size will have a positive influence on farmers' preferences for seed yam and willingness to pay. Seed size was measured at three levels: (1) Small (45kg/100 bunch), (2) Medium (84kg/100 bunch), and (3) Large (180kg/100 bunch). This was included in the estimation as a dummy variable. Further assumption made on seed sizes included: (i) Large size seed yam could be divided into a minimum of five (5) pieces each of 300g; (ii) Medium size seed yam could be divided into three(3) pieces of 300g each; and (iii) A maximum of 150 pieces of 300g could be obtained from 100 bunch of small seed yam.

Purchasing price of seed attributes: The price of certified seed yam is included because it is a major factor that could influence farmers' preferences for seed yam (Boxall and Adamowics, 2002; Birol *et al*., 2012). It is expected that price of seed yam will have a negative influence on farmers' preferences for quality seed yam and willingness to pay. However, considering the output potentials of the certified seed yam, market oriented yam farmers may still prefer quality seed yam and be willing to pay for it. In this case, the *a priori*

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2 Based on data from SRID/MOFA, 2015
3 Based on Data from CRI, 2015

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expectation will be positive. Thus, the effect could be in either direction. Based on the branded nature of the choice experiment, three levels were used to measure prices to account for purchasing prices that corresponded to sizes of seed yam within each brand of seed certification system.

The prices were determined based on prevailing market prices per 100/bunch, percentage certification costs and packaging costs[4]. Given the prevailing seed pricing ratio of 1:2:4 for certified seed: foundation seed: breeder seed, respectively, at CSIR-Crop Research Institute, a scale factor for price addition was calculated as [(2/7)+(4/7)=6/7=0.8571429; this price addition factor was multiplied by the prevailing market prices[5] of seed yam to obtain the mark-up price for quality seed yam (i.e. 100 % certification). This resulted in the following:
Small-sized seed tuber mark-up price per bunch (100 setts) =0.8571429x150=128.57~GHC129
Medium size seed tuber mark-up price per bunch (100 setts) =0.8571429x200=171.43~GHC171
Large sized seed tuber mark-up price per bunch (100 setts)=0.8571429x400=342.86~343
The mark-up price for quality declared seed system is 10% of the respective mark-up prices per the sizes of seed yam. A packaging (sack) cost of Ghc8 was added to the cost of seed yam for semi-declared and quality seed system. Table 1 presents the summary of attributes and levels used in the choice experiment.
It is important to note that although the choice experiments only included five attributes, there were other attributes indicated by Mignouna *et al.* (2014) and Otoo *et al.* (2013) such as ware yam price and uniformity in maturity, among others. Alpizar *et al. (*2003) finds that in choice experiment studies, the researcher has to make a trade-off between being comprehensive (inclusion of all relevant attributes) and the complexity of the choice experiment. In other words, as one tries to include too many attributes in a choice experiment, the associated cognitive demand from respondents in making choices would be too much and respondents may simply answer carelessly or employ some strategic behaviour, which may not be a reflection of their attribute preferences. The five attributes included in this study reflect the balance between their importance and the complexity of task to be presented to farmers.

[4] It should be noted that the price excludes transportation and any other administrative costs
[5] Average market prices corresponding to sizes of the seed yam per bunch were calculated by taking an average of market data of seed prices at Kintampo, Salaga and Ejura and Atebubu yam market. The data was gathered over four months, from November 2014 to February 2015, the period coincides with planting season of yam in Ghana. Although price data was not generated from a market in Afram Plains, the data collected was validated by MoFA and market traders and farmer who sell seed yam. It was established that the seed yam price trend in Ejura and Atebubu was similar to that of Afram Plains.

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Table 1: Definition of choice experiment attributes and their levels

Attributes	Description	Branded choices		
		Informal (Traditional)	Semi-formal (Quality declared)	Formal (Quality)
		Attribute levels	Attribute levels	Attribute levels
Yield potential	Average production harvested per hectare from planting a particular yam variety	6-18t/ha (12t/ha)	16-25t/ha (20.5t/ha)	26-70t/ha (48t/ha)
Percentage certification	Percentage of seed yam that are certified by a regulatory body to be free of pests and diseases	Zero (0) %	10%	100%
Disease infestation	The possibility of disease and pest infestation in seed yam	High (Probability) >60%	Medium(Probability) 10-60%	Low(Probability) <10%
Seed size	The size of seed yam irrespective of the shape per 100 bunch as sorted by traders/farmers	Small (45kg) Medium (84kg) Large (180kg)	Small (45kg) Medium (84kg) Large (180kg)	Small (45kg) Medium (84kg) Large (180kg)
Seed price	Average price of 100 bunch (kg equivalent) of seed yam	Small: Gh¢150 Medium: Gh¢200 Large: Gh¢400	Small: Gh¢184 Medium: Gh¢242 Large: Gh¢477	Small: Gh¢287 Medium: Gh¢379 Large: Gh¢751

Experimental design procedure was employed to structure the choice tasks which were shown to farmers (Hanley *et al*., 2001). Literature indicates several approaches to designing choice experiment (Kuhfeld, 2010; Scarpa and Rose, 2008; Kessels *et al*. (2006); Hensher *et al*., 2005; Blamey, 2001; Sanko, 2001; Louviere *et al*., 2000;). In this study a fractional design via fold over approach was used to create sequential choice sets for the study (see also Sanko, 2001). This is because full factorial design would have would have generated 3^3x3^3x3^3x3 generic choice sets that would be too large to manage (Lusk and Norwood, 2005; Blamey (2001); Louviere et al., 2000; Adamowicz *et al*., 1998; Revelt and Train, 1998).

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Table 2. provides an example of a choice sets used in the experiment.

Table 2: Example of Choice experiment

Attribute	A	B	C	D
	Informal seed	Quality declared (semi-formal)	Quality seed (Formal)	None of them
Yield potentials	6-18t/ha	16-25t/ha	26-70t/ha	I chose not to purchase A, B or C
Percentage certification	0%	10%	100%	
Disease infestation	High	Medium	Low	
Seed size	Small (45kg/100 bunch)	Small (45kg/100 bunch)	Small (45kg/100 bunch)	
Seed price	GHC150	GHC163	GHC279	
Would you buy (…….)	☐	☐	☐	☐

Note: The question asked - Assuming the following seed yam of pona variety were the only type available to you, would you buy- A, B, C or D(not to purchase A, B or C)?

Both paragraph and pictorial presentations were used in the survey. The approaches were combined to overcome the challenge that may result from the low level of education of respondent, and language barrier that may exist in study locations (Birol et al., 2012). Appendix 1 shows the pictorial example of a choice card presented to farmers. Cards showing pictorial presentations of varying levels of attributes were used to show each seed yam certification characteristics. Overall, a total of 9,120 choices were collected from 380 yam farmers that participated in the study. The econometric estimation was conducted using Stata statistical software.

Econometric model

From equation (4), the log-likelihood function maximized in the estimation is:

$$logL = \sum_{n=1}^{N} \sum_{j\in B}^{J} y_{in} \, log \sum_{s=1}^{S} \frac{exp(V_{ni|s})}{\sum_{j\in B}^{J} exp(V_{nj|s})} \text{........(6)}$$

where:

J is the total number of alternatives factor

y_{ni} is the observed frequency of individual *n* choosing alternative *j* within a choice set. This is equal to 1 or 0, as in the conditional logit model. The estimates for λ_S and β_S are attained by maximizing the log-likelihood function.

V_{ni} is a vector of observed variables that includes the seed yam certification traits and

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socioeconomic characteristics of the farmers

S is the vector of the coefficient of attributes for a given class s

$\beta_s^{ASC_i}$ represents the vector of coefficients of the class-specific, alternative-specific constants. The deterministic component of the consumer's utility function is given as:

$$V_{ni|s} = \beta_1 seed\_price + \beta_2 certification2 + \beta_3 certification3 + \beta_4 seed\_size2 + \beta_5 seed\_size3 + \varepsilon$$
(7)

The socio-economic factors influence preference and choice behaviour that entered into the models as interactions with the X's is shown in equation (8). The indirect utility function with interactive terms is presented in equation (8)

$$V_{ni|s} = \beta_1 seed_{price} + \beta_2 certification2 + \beta_3 certification3 + \beta_4 seed_{size} + \beta_5 seed_{size3} + \beta_6 (certification2 * age) + \beta_7 (certification2 * edu + \delta_3 Ceitification2 * yamexperience + \cdots + \beta_{25} \binom{seed_{s3} * seed}{yam\_prod} + \delta_{54} (Miduim\ \ disease\ infestation) * farmsize + \varepsilon$$
(8)

Table 3: Choice experiment variable coding and expected sign used for model estimation

	Branded choices				
	Informal (Traditional)	Semi-formal (Quality declared)	Formal (Quality)		
Attributes	Attribute levels	Attribute levels	Attribute levels	Coding	Expected sign
Percentage certification	Zero (0) %	10%	100%	**Certification 1:** 1=0% and 0=otherwise **Certification 2:** 1=10% and 0=otherwise **Certification 3:** 1=100% and 0=otherwise	Positive
Seed size	Small (45kg)	Small (45kg)	Small (45kg)	Small: 1=45kg and 0=otherwise Medium: 1=84kg and 0=otherwise Large:	Positive
	Medium (84kg)	Medium (84kg)	Medium (84kg)		
	Large (180kg)	Large (180kg)	Large (180kg)		

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	Branded choices				
	Informal (Traditional)	Semi-formal (Quality declared)	Formal (Quality)		
Attributes	Attribute levels	Attribute levels	Attribute levels	Coding	Expected sign
				1=180kg and 0=otherwise	
Seed price	Small: Gh¢150	Small: Gh¢184	Small: Gh¢287	Actual values	Negative
	Medium: Gh¢200	Medium: Gh¢242	Medium: Gh¢379		
	Large: Gh¢400	Large: Gh¢477	Large: Gh¢751		

The socio-economic variables included in the model estimation and analysis are defined in the Table 4.

Table 4: Socio-economic variable definitions and a priori expectations

Variable	Definition	Expected sign
Age	Age of household head in years	-
Experience	Number of years in farming yam	-/+
Active labour force	Number of people in the household who are above 15 years old. This was used as proxy for household labour	+
Income	Total annual income of all income earning household members in Ghana cedis. This includes both farm and non-farm income	+
Educational level	The number of years of formal education of household head	+
Farm size	Total size of yam farm in hectares	+
Extension	Access to extension services measured as dummy variable (1 if farmer has access to extension services and 0=otherwise)	+
Membership	Membership of farmer based organization measured as dummy variable (1 if farmer belongs to a farmer based organization and 0=otherwise)	+

In addition to these socio-demographic characteristics of farmers, factor scores of farmers' perception of quality of seed yam farmers use for yam production were included in the model. The factor scores from 22 statements were generated using principal component analysis with varimax rotation (Boxoll and Adamowicz, 2002). This resulted in seven

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perception factors that were included in the models (see Appendix II).

Estimation of Willingness to Pay

The marginal impacts or the implicit prices for particular attribute were calculated by:

$$MWTP_s = \frac{\beta(Attribute\ level)_s}{\beta(Price)_s} \ldots\ldots\ldots \quad (9)$$

The estimated parameter indicates the value farmers place on seed yam certification attributes in absolute terms. To generate product specific WTP estimates, the formula below (equation 10) was used to arrive at estimated parameters relative to a baseline product (informal certification system).

$$WTP_s = -\frac{1}{\beta(price)_s}\left[ln\left(\sum_{i\epsilon B} exp(coefficient_s\ level_i)\right) - ln\left(\sum_{i\epsilon B} exp(coefficient_s^B\ level_i^B)\right)\right] \ldots..(10)$$

The attribute level is equal to 1 for the attributes related to the specific product and 0 for the features not present, since all the attributes except for the price, had been coded as dummies. Also, an aggregate WTP measure for each attribute was computed by weighing the above class-specific willingness to pay estimates by the class size and summing up as indicated in equation 11:

$$WTP_s = \sum_{s=1}^{S} P(s)\,(WTP_s) \ldots\ldots (11)$$

Where: P(s) is the estimated marginal latent class probability for each segment.

The factors influencing farmers’ preferences and wiliness to pay was determined as post-estimation of the probabilities of belong to a given market segment.

RESULTS AND DISCUSSION

Seed yam market segmentation

The first step in estimating the latent class model is to determine the number of classes or segments to be used as this has direct implications on warfare measures and designing appropriate marketing strategy. Following the works of Kamakura and Russell (1989), Gupta and Chintagupta (1994), Swait(1994), Bhat (1999), Boxall and Adamowicz (2012), and Birol et al., (2012) the minimum of Akaike Information Criterion (AIC) and the minimum of Bayesian Information Criterion (BIC) were used to determine the number of classes/segments.

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Table 5: Criteria for determining the optimal number of segments

Number of segments/classes	Log likelihood function	Number of parameters	AIC	BIC
2	-509.36	35	1088.71	1226.62
3	-371.38	53	848.76	1057.60
4	-330.72	71	803.44	1083.20
5	-330.72	89	839.44	1190.11
6	-329.32	107	872.63	1294.23

Note: The sample size is 9120 choices from 380 households (N).

As shown in Table 5, the log likelihood value at convergence improved as the number of classes increased from 2 to 6 with an increase in the number of parameters. The AIC is minimum at class 4 and the BIC is minimum at class 3. Andrews and Currim (2003) established that the BIC and AIC statistics never under-fit but may sometimes over-fit the number of segments. Over-fitting the true number of segments produces larger parameter bias (Birol *et al*., 2012). Therefore, given AIC is minimized at Segment 4 may over-fit the model. Consequently, three seed yam market segmentation were identified. A latest class model with 3 segments was used in the estimation. The results for the three (3) segment latent class model estimated for Pona variety is presented in Table 6.

Estimated Latent class Model Results

Table 6 presents three different seed yam certification preference groups(segments) with the estimated latent class's probability of 6.32%, 4.74% and 88.95%, respectively. These are the probability that a randomly chosen farmer would belong to first, second and third class/segment, respectively. The first part of Table 6 presents the utility coefficient associated with Pona seed yam certification attributes, while the second section gives the segment membership coefficients. The membership coefficients for the third segment are normalized to zero, to allow the remaining coefficients of the model to be identified in the estimation process (Boxall & Adamowicz, 2002).

The utility coefficient for price variable is negative for all segments. This indicates that farmer in all the segments prefer seed yam with lower prices. This is consistent with economic theory. Farmers in segment one have positive utility towards quality declared seed and fully certified seeds. These are statistically significant at 1% and 5%, respectively. Comparing the magnitude of the coefficient for quality declared and fully certified, it is evident that farmers in segment one (1) attach more value to quality declared seed yam than fully certified seed yam. Farmers in the segments are therefore labeled "*Willing semi-formal seed yam system farmers*".

The segment membership function indicates that farmers in segment are on the average older, less educated, less experience in yam production, they cultivate smaller farm sizes but produce more seed yam as compared to farmers in segment three (3). Also, farmers in this segment perceive that the seed yam they currently cultivate stores well and are less concerned about the seed size.

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Farmers in segment two (2) derive negative utility from both quality declared seeds and fully certified seeds. They are therefore labeled "*Reluctant certified seed yam system farmers*". The segment membership function shows that farmers in this category are older, more educated, have more yam production experience, but cultivate smaller yam farm size and produces less seed yam as compared to farmers in segment three (3). In addition, farmers in segment two (2) experiences less difficulty in obtaining seed yam, have seed yam available in their communities, and/or informal market for seed yam in their localities. Also, the farmers perceive that the seed they cultivate stores for a longer period than farmers in segment three (3).

Farmers in segment three (3) have positive utility towards quality declared and fully certifies seed yam as well as medium sized seed yam attributes. Comparing the magnitude of the coefficient of quality declared and fully certified seed yam, farmers in segment three (3) value fully certified seed yam more that quality declared seed yam. They are therefore labeled "*Willing formal seed yam certification system farmers*".

Table 6: Three-segments LCM estimates for Pona Seed yam

	Segment 1 “Willing Semi-formal seed yam system farmers”	Segment 2 “Reluctant certified seed yam system farmers”	Segment 3 “Willing formal seed yam system farmers”
Utility function seed yam attributes			
Seed price	-0.002 (0.683)	-0.014 (0.338)	-0.034*** (0.000)
Certification2: Quality declared (10% certification)	3.282*** (0.000)	-1.853** (0.026)	2.862*** (0.000)
Certification3: Quality seed (100% certification)	2.055** (0.050)	-1.093 (0.681)	16.821*** (0.000)
Seed size: Medium (84kg/100 bunch)	0.646 (0.359)	2.117 (0.389)	6.724*** (0.000)
Seed size: Larger (180kg/100bunch)	-0.074 (0.966)	5.640 (0.249)	15.735 (0.560)
Segment membership function			
Farmer characteristics			
Constant	-4.396*** (0.008)	-3.518** (0.011)	-
Age	0.031 (0.134)	0.024 (0.283)	-
Education	-0.040 (0.529)	0.066 (0.303)	-
Yam production experience	-0.041 (0.118)	0.019 (0.471)	-
Yam farm size (hectares)	-0.0005 (0.996)	-0.602** (0.054)	-
Seed yam production	0.950 (0.519)	-0.654 (0.474)	-
Seed yam perception indicators			
Factor1	0.082 (0.712)	-0.377* (0.099)	-
Factor2	-0.013 (0.953)	-0.511* (0.079)	-
Factor3	0.300 (0.244)	-0.449* (0.070)	-
Factor4	0.753 *** (0.010)	0.550* (0.051)	-
Factor5	0.245 (0.273)	0.074 (0.778)	-
Factor6	-0.446** (0.026)	0.085 (0.762)	-

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Factor7	0.008 (0.970)	-0.352 (0.151)	-
Log likelihood		-334.477	
ϱ^2		0.0581	
Sample		9120	

Note: Coefficient significant at 10% (*), 5%(**), 1%(***); Z-statistics in parenthesis

Willingness to pay for Certified Pona seed yam attributes

The marginal value of each seed yam attribute shows the farmer's willingness to accept (WTA) compensate to forego an attribute or marginal willingness to pay (WTP) to adopt an attribute. Table 7 shows the marginal values estimated for the three segments. The estimated figures represent the farmers' WTA compensation (in Ghana cedis) in order to forego an attribute or WTP (in Ghana cedis) to adopt an attribute.

Table 7: Segment specific valuation/willingness to pay for certified pona seed yam attributes (¢[6])

Seed attributes	Segment 1: Willing Semi-formal seed yam system farmers	Segment 2: Reluctant certified seed system farmers	Segment 3: Willing formal Seed system farmers
Certification-10% (Quality declared)	388.3*** (-396.3-1173.0)	-293.9*** (-997.9 -410.0)	74.4*** (-148.7-297.5)
Certification-100% (Quality)	255.8** (-87.3- 598.8)	144.9 (-723.4-1013.3)	719.9*** (-874.9-2314.8)
Seed size: Medium (84kg/100 bunch)	101.0 (62.2-264.3)	499.0 (-853.2-1851.2)	12.5*** (-170.4-195.4)
Seed size: Larger (180kg/100bunch)	58.9 (-270.8-388.6)	1,374.0 (-2011.2-4759.3)	-12.6*** (-461.6-436.4)

Wald procedure was used to generate t-statistics. Coefficient significant at 10% (*), 5%(**), 1%(***); 95% confidence interval in parenthesis;

Farmers in segment 1 place more value on quality declared pona seed yam than fully certified seed yam. They are willing to pay Gh¢388.3 for a bunch of quality declared pona seed yam. This is Gh¢132.5 higher than what they are willing to pay for fully certified seed yam.

[6] 1USD=3.8GH¢

Farmers in segment 2 value quality declared seed yam and fully certified seed yam differently. These farmers are willing to accept Gh¢293.9 for a bunch of quality declared seed yam. In other words, for a farmer in segment 2 to adopt a bunch of quality declared seed yam, he/she must be compensated Gh¢293.9 in order to be satisfied. This could be in the form of subsidies or given free of charge at least for a start. To such farmers, the adoption of certified seed yam would reduce their utility because their do not see any challenge with the quality of seed yam they cultivate.

Farmers in segment 3 are willing to pay for both quality declared seed yam and fully certified seed yam but the magnitude varies significantly. Farmers in the category are willing to pay Gh¢719.9 to adopt a bunch of fully certified seed yam. This amount is about 10 times greater than the amount they are willing to pay for quality declared seed yam.

Farmers show more utility towards medium sized seed yam as compared to smaller and large size seed yam. Although the farmers in segment 3 were willing to pay Gh¢12.5 in order to adopt medium sized seed yam, they are willing to accept a similar amount free of charge in order to adopt large size seed yam.

The results demonstrate that farmers do not look for a single attribute of the variety when making their seed selection decisions. This finding lends support to the work by Asrat *et al*. (2010) and Acheampong (2015), who found that farmers were willing to make trade-offs in order to obtain yield stability in Ethiopia and Ghana, respectively. This, however, contrasts that of Mendis and Edirisinghe (2014) who found high positive WTP for yield attribute in their study of farmers' WTP for rice traits in Sri Lanka. Furthermore, the results demonstrate that farmers are willing to pay for certified seed yam certification and provide impetus for the establishment of commercial seed yam certification system in Ghana. They are willing to pay Gh¢388.3 for quality declared pona seed yam and Gh¢719.9 for a bunch of fully certified seed yam. These amounts could respectively serve as a guide in pricing certified seed yam, among other factors.

Characteristics of farmers belonging to each segment

The characteristics of farmers belonging to each segment were analysed based on the predicted probabilities of farmers belonging to each segment. The results are shown in Table 8.

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Table 8: Characteristics of farmers belonging to the three segments

Variable	Segment 1: Willing Semi-formal seed yam system farmers (N=23, 6%)	Segment 2: Reluctant certified seed system farmers (N=18, 5%)	Segment 3: Willing formal Seed system farmers (N=339, 89%)
Farmer's age (years)***	46.30 (19.54)	51.78 (20.01)	44.78 (13.75)
Farmer's education (years)	2.70 (3.00)	3.22 (4.36)	2.71 (3.71)
Farmer's experience (years)***	17.43 (11.28)	28.17 (13.90)	20.78 (12.71)
Yam production experience (years)**	17.09 (11.44)	25.28 (14.71)	19.68 (12.89)
Total land holdings (hectares)**	3.40 (2.79)	2.43 (1.40)	4.00 (4.76)
Yam farm size (hectares)***	1.86 (1.68)	1.26 (0.76)	2.13 (2.77)
Income from yam*** production (2014) (GHC)	4443.48 (5434.78)	3063.89 (3376.09)	5692.45 (9183.81)
Total household income (GHC)**	6556.52 (8159.17)	5287.78 (5367.21)	8841.09 (13214.60)
	Percent		
Seed yam production	100	88.9	93.2
District			
Kintampo	13.01	6.50	80.49
East Gonja	1.50	6.02	92.48
Afram plains	4.03	1.61	94.35

Note: Mean (standard deviation in parenthesis); Note: T-test and Pearson Chi-square test shows significance difference at 5%(**), 1%(***) level

The results show that farmers who are reluctant to seed certification system are older, have more farming and yam production experience and have access to and cultivate less yam farm as compared to farmers in segment 1 and 3. Also, such farmers obtain less income from yam production and have less household income as compared to farmers in other segments. The findings on age, experience and income are consistent with that of Birol et al (2012) about the characteristics of reluctant Bt maize farmers in Philippines.

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CONCLUSIONS

The study employed choice experiment method and latent class model was used to assess (a) the existence of market segmentation that way require differential interventions; (b) farmer's preferences for Pona seed yam certification system and (c) their Willingness to Pay for certified Pona seed yam. The study identified three classes/ market segments of farmers regarding preferences for *Pona* seed yam. However, the majority (88.9%) preferred fully certified seed yam for *Pona*.. The findings indicate that the likelihood that a randomly chosen farmer would prefer fully certified seed yam was 88.9%. These farmers were willing to pay ¢719.6 for a bunch of seed yam with 100 percent certification. Farmers also had high utility towards medium sized seed yam for Pona variety and were willing to pay ¢12.5 for this attribute. Furthermore,the study finds that age, yam production experience, farm size and income level were the factors that influence farmers' preferences and willingness to pay of certified seed yam. Farmers who were less willing to pay for certified seed yam were older, cultivated smaller yam farms, had more experience in yam production but had less household income compared to farmers who preferred certified seed yam.

The results lay credence to the need to establish commercial seed yam certification system to ensure sustainable supply of quality seed yam to enhance productivity. There is the need to strengthen the National Agricultural System (NAS) to develop appropriate guidelines for seed yam certification in Ghana. This could be done by adapting existing seed certification guidelines for other crops, and in collaboration with existing or potential seed producers. The results demonstrate market potentials for seed yam in Ghana. Commercial seed producers should take advantage of this market potential to produce and supply quality seed yam to farmers. Seed producers should target younger farmers and yam farmers who cultivate larger acreage of yam farm. The study findings should provide a guide to certified seed yam producers in setting seed prices. The findings of the study did not support the need to design differential sed yam marketing strategy.

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Appendices

Appendix 1

Figure 4.5. An example of choice card

	A	B	C
Attribute	Informal seed	Quality declared (semi-formal)	Quality seed (Formal)
Yield potentials	 6-18t/ha	 16-25t/ha	 26-70t/ha
Percentage certification	None 0%	 10%	 100%
Disease infestation	 High	 Medium	 Low/None

Seed size	 Small (45kg/100 bunch)	 Small (45kg/100 bunch)	 Small (45kg/100 bunch)
Seed price	 GHC150	 GHC163	 GHC279

Appendix 2

Factor analysis/correlation   Number of obs   =   380
Method: principal-component factors   Retained factors =   7
Rotation: (unrotated)   Number of params =   133

Factor	Eigenvalue	Difference	Proportion	Cumulative
Factor1	3.03515	0.25542	0.1380	0.1380
Factor2	2.77973	1.08838	0.1264	0.2643
Factor3	1.69135	0.26781	0.0769	0.3412
Factor4	1.42354	0.12282	0.0647	0.4059
Factor5	1.30071	0.14804	0.0591	0.4650
Factor6	1.15267	0.06867	0.0524	0.5174
Factor7	1.08400	0.12748	0.0493	0.5667
Factor8	0.95652	0.03133	0.0435	0.6102
Factor9	0.92519	0.04967	0.0421	0.6522
Factor10	0.87551	0.03841	0.0398	0.6920
Factor11	0.83710	0.05914	0.0381	0.7301
Factor12	0.77796	0.03597	0.0354	0.7654
Factor13	0.74199	0.12010	0.0337	0.7992
Factor14	0.62189	0.01917	0.0283	0.8274
Factor15	0.60271	0.04471	0.0274	0.8548
Factor16	0.55801	0.01458	0.0254	0.8802
Factor17	0.54343	0.03663	0.0247	0.9049
Factor18	0.50680	0.06010	0.0230	0.9279
Factor19	0.44670	0.01958	0.0203	0.9482
Factor20	0.42712	0.03612	0.0194	0.9676
Factor21	0.39100	0.07008	0.0178	0.9854
Factor22	0.32092	.	0.0146	1.0000

LR test: independent vs. saturated: chi2(231) = 1514.06 Prob>chi2 = 0.0000

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