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Analysis of farmers' valuation of common bean attributes and preference heterogeneity under environmental stresses of Kenya

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This study uses a choice experiment method to quantify farmers' valuation of key bean variety attributes under different climatic conditions of Kenya and assess their willingness to pay or accept for changes in those attributes. The study also tests for the gender related heterogeneity in attribute preferences at individual and household level while accounting for differences in production scenarios to understand when and where men and women preferences begin to diverge or converge. The key common bean attributes were: yield, tolerance to environmental stresses (intermittent drought and root rot), early maturing, taste and reduced cooking time. Choice data was collected from random selected 504 households from purposively selected districts of high drought prone areas and high rainfall parts of Kenya. A random parameter logit model with interactions that accounts for random heterogeneity and conditional heterogeneity was used to derive unbiased estimates. Results indicate that all attributes are important but farmer derive higher utility from changes in consumption and post-harvest attributes compared to those in production attributes. Farmer valuation of the changes in yield, tolerance to environmental stresses and cooking time are heterogeneous, partly explained by size of the household, gender, risk aversion and market access. Men generally are likely to derive higher values from improvements in these attributes than women. Results have important implications for breeding priority setting, seed dissemination and integration of gender into bean improvement research.

Key word: Choice experiment, bean attributes, gender, Kenya.

INTRODUCTION

Common bean (*Phaseolus vulgaris* L.) plays an important and diverse role in the farming systems and in the diets of many people in Kenya. The crop occupies about one million hectares of land annually (FAO, 2015) and ranks second after maize as a food security crop in the country It is typically grown by smallholder farmers (mainly

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women[1]), often in marginal environments with few inputs under multiple cropping systems. Consequently, the crop is curtailed by environmental stresses, notably, drought; declined soil fertility (Kimiti et al., 2009; Odendo and Kalyebara, 2004) and diseases such as bean root rot (Odendo et al., 2004). Drought that manifests in two distinct broad forms (terminal and intermittent) is widespread, often intense and cause up to 60 percent yield loss (Katungi et al., 2010). Varietal adaptation to the environment, recognized as an efficient strategy to minimize vulnerability to risk (Dercon, 1998) has been the primary strategy used to address the problem of bean production constraints in Kenya. For over two decades, the International center for Tropical agriculture (CIAT), through the Pan African Bean Research Alliance (PABRA 2015)[2] has been collaborating with bean program of Kenya, to enhance bean resistance to drought and diseases. Over 49 improved bean varieties, some of which with shorter maturity period, capable of escaping terminal drought and resistant to diseases (e.g root rot) have been released since 1980 (PABRA data base, 2015). However, few of these varieties have been taken up by farmers and common bean productivity in the country remains one of the lowest in the region (FAOSTAT, 2014).

Breeders at CIAT, national agricultural research systems and universities have been undertaking research to increase the levels of bean tolerance to drought and soil pathogens (Beebe, 2012). Tolerance to drought and soil pathogens that has been previously improved through intraspecific crosses, employing the naturally occurring variability within P. vulgaris (Beebe et al., 2008), is now being extended to interspecific crosses with sister species of the genus Phaseolus (Beebe, 2012). Success in this effort is expected to improve adoption of improved varieties, impacting positively on bean productivity through reducing yield loss. However, the process of increasing variety resistance could alter the levels of other attributes that farmers also value, consequently affecting potential adoption and expected impact. It is therefore, crucial that breeders understand how farmers respond to changes in the important variety attributes in order for them to know where and when trade-offs are possible.

This paper applies a stated preference elicitation method (that is, choice experiment) to investigate how farmers value bean variety attributes: drought and disease tolerance, yield, taste and cooking time. These attributes have been identified in the literature as most popular on farmers' variety selection criteria (Graf et al., 1991; Sperling et al., 1993; Odendo et al., 2004; Katungi et al., 2011a). Previous studies have used qualitative assessment methods to rank the farmer preferences of these attributes (Sperling et al., 1993; Odendo et al., 2004). Compared to qualitative methods, choice experiment analysis estimates the magnitude of the trade-offs that farmers are willing to accept and the potential welfare gains associated with a change in the levels of the attributes. The choice experiment method has been used in valuation of non-marketed genetic resources for in-situ conservation programs (Drucker and Anderson, 2004; Asrat et al., 2009), and in the ex-ante evaluation of welfare impacts of technologies not yet available on the market (Birol et al., 2011; Kikulwe et al., 2011); similar to the case we analyze. Information from this study is important for breeders and policy makers. Beeders can use it to determine the most prefered combination of attributes in varieties while policy makers are interested in knowing the economic benefits and costs in order for them to make informed decisions regarding resource allocation.

Based on the choice experiment, we also assess whether men and women farmers value common bean variety attributes differently. The empirical inquiries and experience from participatory plant breeding has shown that men and women sometimes have distinct objectives and constraints, which are likely to shape their preferences for different crop attributes (Bellon, 2002; Paris et al., 2001). Since the choice experiment data was collected from men and women respondents in randomly selected households, we include gender of the respondent in the analysis and evaluate its effect on attribute demand and trade-offs. The willingness to pay or accept changes in the levels of each attribute is also computed separately for male and female headed household; and compared to derive implications for breeders on gender differences, so as to influence technology targeting. Finally, farmer preference heterogeneity is analyzed under different scenarios of environmental stresses characterized by severe drought and high rainfall conditions to provide more insights on how preferences vary across agro-ecological conditions.

MATERIALS AND METHODS

Econometric framework

In a choice experiment, the respondents' preferences are observed in terms of their choices assumed to be made based on the utility they derive from the characteristics of the goods (Lancaster, 1966). Then, the responses to the different choice sets are modeled based on the random utility (McFadden, 1974) as a function of the choice of attributes (representing respondents' preferences), expressed in vector, Z_{ij}, and an error term, ε_{ij}. Assuming a linear relationship in the parameters and variables between utility and attributes, and the error terms that are identically and independently distributed, the utility (V_{ij}) for alternative j derived by farmer i can be expressed as:

[1] Men and women participate in crop production, but women contribute more (57%) of the labour used and take a leading role in activities related with variety selection and seed management (Katungi et al., 2010).

[2] The Pan African Bean Research Alliance (PABRA) is an African research for development program comprising of three regional networks--- that cut across 30 countries in eastern and central Africa (ECABREN), southern Africa (SABRN) and West Africa (WECABREN), supported by different donors, other public, private and non-governmental organizations in various ways.

$$V_{ij} = \lambda' Z_{ij} + \beta_p \Pr_{ij} + \varepsilon_{ij} \quad (1)$$

Where λ is a vector of parameter coefficients to be estimated including an alternative specific constant (ASC), while $\Pr_{ij}$ is the price attribute for alternative j and β_p is the price parameter. The assumption of the distribution of the error term implicit in Equation 1 imposes a restriction that the probability of a particular alternative being chosen is independent of the irrelevant alternatives (IIA)[3]. When this assumption holds, Equation 1 can be estimated by a conditional logit model (CLM). However when the assumption breaks down and all or some of the attributes are random, it means that each respondent's coefficient vector λ is the sum of the population mean $\bar{\lambda}$ and individual respondent deviation γ_j from the mean. The indirect utility to be estimated becomes:

$$V_{ij} = (\bar{\lambda} + \gamma_j)' Z_{ij} + \beta_p \Pr_{ij} + \varepsilon_{ij} \quad (2)$$

In Equation 2, the stochastic component is now explicitly a component of the individual-specific deviations from the population mean $\bar{\lambda} Z_{ij}$ and ε_{ij}; and is correlated across alternatives. The IIA null property was tested according to the procedure of Hausman and MacFedden (1984). The property of the IIA was significantly violated at 1% level when at least one of the three choice options was dropped, indicating that the models do not completely conform to the underlying IIA property. Based on this test, it is interpreted that the choice preferences in our sample are not homogenous and the conditional logit (CLM) models produce biased estimates.

Econometric models alternative to the standard conditional logit commonly used include, the random parameter logit, RPL, (Oparinde and Birol, 2012; Rigby and Burton, 2005; Greene and Hensher, 2003; Greene and Hensher, 2003; McFadden and Train, 2000; Rigby and Burton, 2005; Train, 1998) and the latent class model, LCM, (Kikulwe et al., 2011; Birol et al., 2011; Louviere et al., 2000; Swait, 1994). Both the RPL and LCM incorporate heterogeneity in attributes, the systematic component of utility, but are based on different assumptions about the heterogeneity distribution. The RPL assumes a continuous distribution of the parameters to introduce heterogeneity; while the LCM uses discrete classes to reach the same.

A random parameter model (RPL) that is not affected by IIA assumption also used by others (e.g., Oparinde and Birol, 2012; Rigby and Burton, 2005; Greene and Hensher, 2003) was employed in the estimation. In the RPL models, distributions for the choice parameters that are deemed to be random are specified and parameters estimated for those distributions. The RPL has been criticized for its failure to account for scale heterogeneity in favour of generalized mixed logit model proposed by Fiebig et al. (2010). However, the analysis by Greene and Hensher (2010) reveals that scale heterogeneity may not be of such great empirical consequence in respect of behavioural outputs such as direct elasticities and willingness to pay. Since the willingness to pay or accept was our main interest, the RPL is appropriate for the analysis. The random parameter logit model, however, fails to explain the sources of heterogeneity even though it accounts for unobserved heterogeneity (Boxall and Adamowicz, 2002). To detect the sources of heterogeneity while accounting for unobserved heterogeneity, interactions of respondent-specific characteristics with the choice-specific attributes were included in the utility function. The RPL models with interactions can detect preference variation in terms of the unconditional heterogeneity of tastes (random heterogeneity) and individual characteristics (conditional heterogeneity) that are hypothesized to influence preferences for attributes, thereby improving the fit of the model (Revelt and Train, 1998; Morey and Rossmann, 2003). When the interaction terms are included, the indirect utility function that is estimated follows the specification in Rolfe et al. (2000) and is expressed as:

$$V_{ij} = (\bar{\lambda} + \gamma_j)' Z_{ij} + \alpha' X_{ij} + \beta_p \Pr_{ij} + \varepsilon_{ij} \quad (3)$$

Where X_{ij} is a vector of interaction terms between bean variety attributes that are random and farmer's characteristics that remain constant across choices made for any given farmer, and α is a vector of interaction term parameters to be estimated.

In developing countries, farmers' preferences for crop variety attributes are often relatively heterogeneous because of variations in resource endowments such as size of landholding, labour, and capital for farming (Bellon and Reeves, 2002). Farmers who are resource constrained and therefore at the risk of starvation are expected to derive higher values from variety attributes such as tolerance, early maturing, that reduce their vulnerability to risk of crop failure. Similarly, farmers whose households have a relatively higher dependency ratio[4] are more vulnerable to risk of crop failure and are likely to derive higher values from risk reducing variety attributes.

Individual specific characteristics hypothesized to influence the preferences for bean variety attributes were education and gender. However, education was correlated with gender and hence excluded from the model. Reduced cooking time also provide higher utility to households that lack resources to support extended cooking (Katungi et al., 2011a). Since, women undertake most of the household chores, including food preparation, we expected female respondents to derive higher values from reduced cooking time than male respondents. However, when the burden of gathering fuel wood is shared, or undertaken by men, then men would also derive higher values from bean varieties with reduced cooking time. Hence, the effect of gender cannot be predicted a priori.

Using Nlogit 4[5] we estimated the random parameter logit models with simulated maximum likelihood using Halton draws with 100 replications. The maximum likelihood algorithm searches for a solution by simulating k draws from distributions with given means and standard deviations. The probabilities are calculated by integrating the joint simulated distribution. In order to capture the marginal utility of income, willingness to pay (WTP) estimates were derived. The derived estimates denote the percentage change in price that farmers are willing to pay as a premium (or discount) for a change in the level of each bean attribute embedded in variety seed. This WTP is calculated as (cf. Louviere et al., 2000):

$$\boldsymbol{WTP} = -\lambda / \beta_p \quad (5)$$

Where λ is an estimated mean or standard deviation parameter of the product-specific attribute for the RPL model, and β_p is the estimated price coefficient. A Delta method is used to obtain the standard errors of derived WTP values.

[3] the intuition behind IIA assumption is that the value of choice made is to be judged only by the consideration of features related to that choice rather than a value in part related to what else could have been chosen.

[4] Computed as the number of children younger than 15 years of age and members older than 65 years old divided by the number of adults aged 15 to 64

[5] NLOGIT Version 4 is a statistical software that provides programs for estimation, model simulation and analysis of multinomial choice data.

Table 1. Attributes, their definitions, levels and coding.

Attribute	Variables	Description	Levels	Coding
Yield	Yield	Number of pods per plant;	5, 10, 15	Actual values
Maturity time	Mattime	Number of days to maturity;	60, 75, 90	Actual values
Tolerance	Tolerance	Tolerance to drought/disease levels (%)	0, 30, 50	Actual values
Taste	Tastebetter	Better taste after cooking	Better (1), moderate (-1)	Effect-coded
	Tastebad	Bad taste after cooking	Bad (1), moderate (-1)	Effect-coded
Cooking	Cookshort	Short cooking time	Short (1), moderate (-1)	Effect-coded
	Cooklong	Long cooking time	Long (1), moderate (-1)	Effect-coded
Price	Price	Change in price (%)	0 (100), 15(115), 30(130)	Actual values

Note: [1]Tolerance to environmental stresses was represented as drought for eastern province and diseases for Western region.

Choice experiment design

The first step in designing a choice experiment study to value crop variety attributes is the definition of a crop variety in terms of its attributes and the levels taken by these attributes. The definition of common bean attributes was done in consultation with the National bean scientists in Kenya, CIAT bean breeders and key informants in the selected communities while drawing from the literature. Important attributes of a common bean variety have been identified through previous research in broader terms, as yield; earliness, resilience to environmental stress, taste, cooking time and price (Sperling et al., 1993). The level of each attribute was chosen in accordance with the existing situation in the study area and relevance to the consumer. This was accomplished in consultation with the breeding scientists in the bean program of Kenya at Katumani and key informants, also guided by the literature on farmer preferences of common bean (Sperling et al., 1993; Katungi et al., 2011a). Table 1 shows the attributes selected for the analysis, their respective definitions and levels as collectively designed.

The first three attributes: yield, maturity period and tolerance to drought (or diseases) characterize the relative agronomic advantage of a bean variety and have been a major focus in bean breeding (Beebe, 2012). The yield attribute is commonly measured in standard metric units (kg/unit area) in the market, but bean farmers rarely use standard measures at harvest or marketing and are often not sure of yield in standard metric units. They, however, can tell a variety yielding potential by visual inspection on the number of pods per plant and define it as high yielding if it has many pods (15-20), medium yielding (10-15 pods) and low yielding if it has 10 or less pods[6]. This definition of yield attribute was preferred over the standard metric as it is easy for farmers to interpret and can be directly attributed to the variety genetic improvement when other factors are uniform.

The tolerance to environmental stress (drought /disease) attribute was described based on the context. In eastern Kenya, drought was the environmental stress considered in the study. In this region, drought can be exhibited either in form of mid-season gaps (also referred to as intermittent drought) or inadequate amounts of rainfall. A bean variety with increased level of tolerance to drought as compared to the current existing ones should have the capacity to withstand inadequate soil moisture and yield loss would be less. At harvest, an adopter will be able to get relatively higher harvest compared to a non-adopter under similar production environments. The attribute tolerance to drought was defined in relative terms as a percentage change in yield when there is drought because we do not have information on the absolute yield advantage of the improved varieties over currently grown ones, the opt-out option. The percentage change helped us to accommodate a range of drought scenarios across the study sites as well as flexibility in the opt-out option, which is household specific. Attribute levels were then defined as: no benefit (0%) meaning that the variety is not tolerant at all compared to current farmer varieties, small benefit (30%) the yield loss remains high when the stress occurs and large benefit (50%) interpreted that yield loss due to stress is substantially reduced. The definition and measurement of the attribute to tolerance to diseases in Western Kenya was defined based on the same approach as that used in case of drought. A variety with increased level of tolerance to diseases as compared to current existing ones was described as that with the capacity to withstand high disease pressure, relatively curbing down yield loss.

The attribute of maturity time represents the number of days a variety takes to complete its growing cycle, from planting–through flowering to full maturity ready for harvest in dry form. The attribute levels were defined as: short = 60-70 days; medium = 75-85 days and long = 85-90 days (Wangara and Kimani, 2007). Experience from the participatory variety selection activities indicates that farmers have repeatedly demonstrated preference for earliness in beans though for different reasons. In a drought stressed environments, short growing cycles enables bean varieties to utilize minimum rainfall to grow, enable food insecure households to access food quickly and land constrained households in high rainfall areas, are able to plant a second crop in the same cropping season after harvesting beans. However, when drought manifests itself in form of mid-season gaps, drought tolerant varieties depend on deep rooting system to survive (Beebe et al., 2008), but this might be accompanied by prolonged growth cycle. Hence, it is important to understand whether farmers would accept such trade-offs.

Taste is a difficult attribute to measure using a standard definition because it is how food feels in the mouth, which is subjective and depends on factors such as method of cooking and individual preferences. Nevertheless, it was included and defined in relative terms reflecting a hypothetical situation if it was to change from the status quo to better or bad. This enabled us to estimate how farmers, as consumers value the taste attributes and are willing to pay or accept compensation for a change in the attribute. The time it takes dry bean grain of a hypothetical variety to cook ready for consumption is also subjective as it depends on the type of cooking fuel and container used, both of which vary across households. Attribute levels were defined in qualitative manner as: short, medium and long. Finally, the hypothetical change in price of seed was included to enable estimation of the monetary value of each attribute. Percentage changes were used and the levels determined

[6] The same approach is used by farmers to select varieties with high yielding potential during participatory variety selection process (Sperling et al., 1993). The corresponding number of pods was determined in consultation with breeders in KARI and CIAT

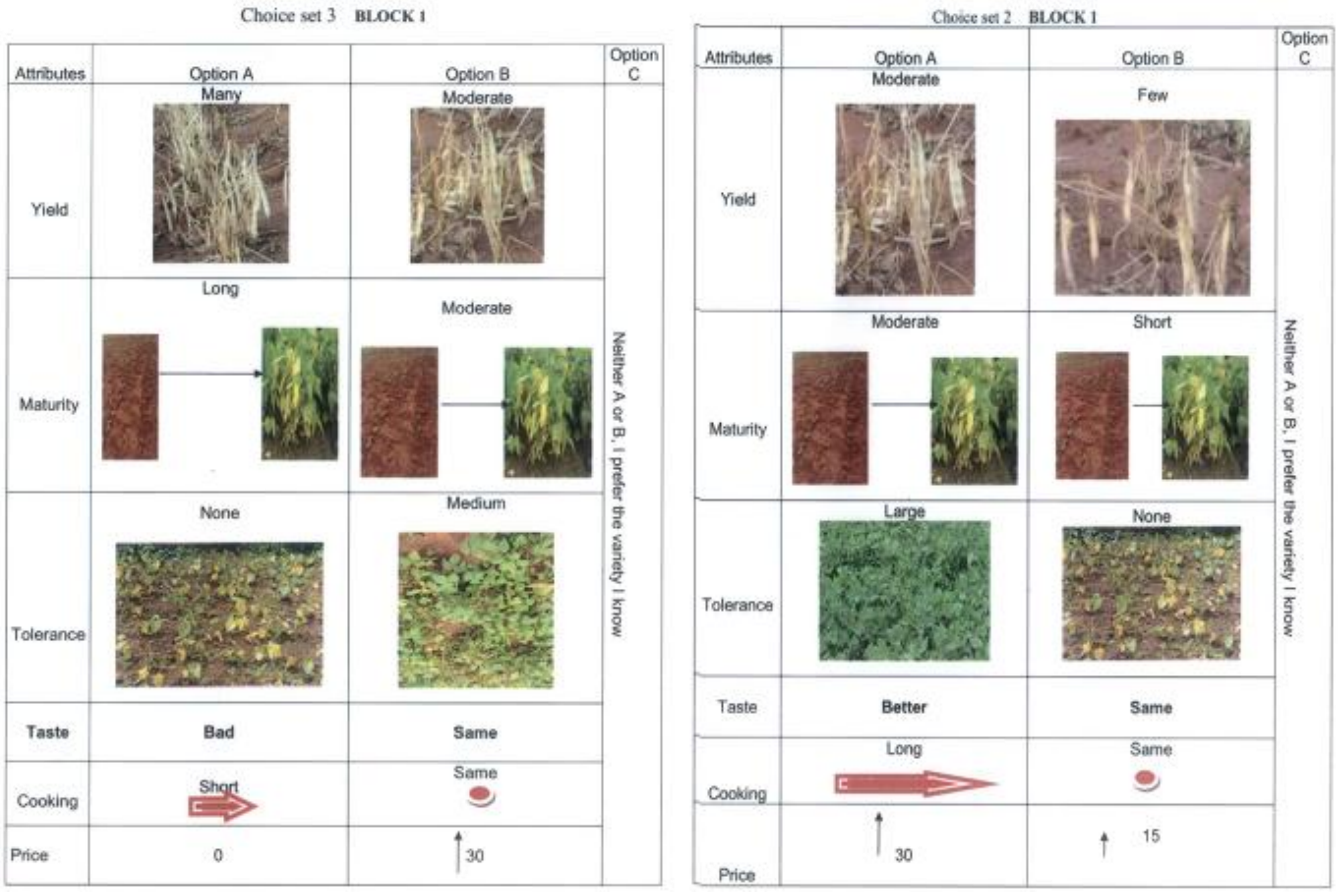

Figure 1. Example of variety alternatives: cards used in the choice experiment.

from the range of price.

Then, using statistical methods, attribute levels were combined to represent a specific variety alternative. Experimental design methods (Louviere et al., 2000) were used to structure the presentation of the six bean variety attributes and their levels into choice sets. D-Optimal/efficiency experimental designs with only the main effects were constructed using the SAS software (see Kuhfeld (2010) and Johnson et al. (2007)), resulting into 18 efficiently designed choice sets, each containing two bean seed alternatives (seed profile A and B) and an opt-out alternative by selecting neither of the presented bean profiles. The 18 choice sets were randomly blocked into 3 versions, each containing 6 choice sets. Each variety profile was presented on a card (Figure 1).

Study area, survey implementation and sample characteristics

The study was conducted in two regions of Kenya, selected to represent: 1) very high drought stress environment in Eastern province of Kenya, and 2) high rainfall but high diseases stressed parts of western Kenya. In both regions, common bean is the most important pulse, consumed almost daily. As a matter of fact, per capita bean consumption as high as 66 kg/year in parts of Western Kenya have been reported in Broughton et al. (2003). The Eastern province receives about 500-750 mm of rainfall annually (Mwita et al., 1981), which comes twice a year (October – December and March to May). Rainfall patterns are highly variable, often resulting in severe food shortages and repeated food aid (Sperling, 2002). The soil types are predominantly sandy and murram with patches of black cotton soils (vertisols) in poorly drained areas (Mwita et al., 1981). In terms of bean area, the province accounts for 35% of the national production (Okwiri et al., 2009). Study site in Western Kenya also receives bimodal type of rainfall that varies between 1000-1800 mm per annum, much higher compared to that experienced in the Eastern province. The soils are well drained, deep to extremely deep dark reddish brown friable clay, friable sandy clay loams and brown sandy loams. This is a high production potential hub of Kenya but agriculture is increasingly being constrained by land shortage and the associated diseases such as root rot (Buruchara, 2003).

With the help of agricultural extension and community development workers, two districts were purposively selected from each region to represent the production context of interest. Then, the primary sampling units and households were selected based on random sampling techniques. The number of households per primary sampling unit was fixed at 42 due to budget limitations and selected from the lists compiled by Assistant Chiefs based on simple random sampling (using a random start). The final stage involved random allocation of the selected households to the three experimental blocks, with each block receiving 14 households per sub-location, totaling 168 households across the entire sample. The summary of the sample and its distribution of sampling units are reported in Table 2. Where the selected farmer was not willing to respond or could not be found, the household was replaced by another one directly on the list also selected randomly as substitutes, but cases that required substitution were very few.

Table 2. Study regions, districts, sub-locations and distribution of the sample into blocks by sub-location.

Region (secondary sampling unit)	District	Sub-location (primary sampling unit	Block 1	Block 2	Block 3	Total
Eastern Province (very high drought stress environment)	Mwala	Mbiuni	14	14	14	42
		Kyanganga	14	14	14	42
		Makiliva	14	14	14	42
	Kathiani	Mitaboni	14	14	14	42
		Kaiani	14	14	14	42
		Ngiini	14	14	14	42
Western Province (high rainfall but high diseases stressed)	Bungoma central	Mutulo	14	14	14	42
		Webuye	14	14	14	42
		Sitikho	14	14	14	42
	Bungoma East	Sikulu	14	14	14	42
		Sichei	14	14	14	42
		Chwele	14	14	14	42
		Total	168	168	168	504

Individual interviews were conducted by well-trained enumerators selected from the study communities to ensure good rapport with respondents for maximum cooperation throughout the interview. Before the interview, each enumerator gave an introduction explaining to the respondent the purpose of the study. Respondents were informed about the hypothetical bias problem of choice experiments through “cheap talks”, and assuring them that there is no right or wrong answer but the study seeks to know their preferred choices in each choice situation. At the time of interviews, attributes whose levels were measured in percentage were first translated into absolute numbers with the help of respondent. Each respondent was asked the actual status e.g price and using percentages scale, the changes were computed and translated into actual figures to enable the respondent visualize the differences. This was done for all attributes measured in percentage changes. In addition to choice data, the survey gathered information on household characteristics including demographic, assets, land holdings and utilization, knowledge on bean varieties, market access, food security and other socio-economic characteristics of the farm.

Descriptive statistics presented in Table 3 reveal significant differences between sampled sites. Generally, the sampled sub locations (study sites) from Kathiani district were more remote compared to other districts, though this did not seem to influence the marketed surplus, as the average share (less 20%) of marketed harvest was small for all sub-locations. On average, landholdings are small but much smaller for female headed households in the study sites of Western Kenya. Despite land shortage, food security was more frequent in the study sites in Western region compared to Eastern region, due to favourable climatic conditions in the former region. While about 17.5 and 22% of the households in Western and Eastern study sites were headed by females, the respondents from some of the male headed households were females. This allowed us to analyze differences in preferences and valuation between men and women respondents who are also farmers.

RESULTS AND DISCUSSION

In the analyses not shown here, conditional logit (CL) models were estimated and all the variety attributes included in the study were found to significantly explain the choices. Since the CL models were found to violate the IIA assumption, the model was augmented by employing a random parameter logit model (also referred to as mixed logit), not affected by IIA assumption. In the random parameter logit (RPL) models, distributions for the choice parameters that are deemed to be random are specified and parameters estimated for those distributions. Variables: maturity time (*mattime*), better taste (*tastebetter*), bad taste (*tastebad*), long cooking time (*cooklong*) and price were fixed (non-random variables), while yield (*yield*), tolerance to environmental stresses (*tolerance*), and short cooking time (*cookshort*) variables were allowed to vary (random variables) and assumed to be normally distributed (Train, 1998; Carlsson et al., 2003). The results reported in Table 4 revealed that

Table 3. Mean values and respective standard deviations (parenthesis) of the sampled households, by province and gender (male headed and female headed households).

Characteristic	Western Kenya			Eastern Kenya		
	Female headed (N=55)	Male headed (N=197)	All	Female headed (N=43)	Male headed (N=209)	All (N=504)
Land Size (acres)	0.61 (0.46)	0.63 (0.51)	0.63***(0.50)	1.04(0.9)	1.03(0.51)	1.03***(0.95)
Type of household (%)	22	78	-	17	83	-
Gender of respondent (=1 if male)[NB]	0.24***(0.43)	0.45***(0.5)	0.41**(0.49)	0.33**(1.25)	0.58**(0.67)	0.54**(0.8)
Age household head	50 (15.4)	46.6(15.3)	47.4(15.3)	54.1(13.9)	53.4(12.3)	53.6(12.6)
Household size	8.42(5.02)	10.37(5.23)	10.25(5.18)	8.86(5.5)	9.06(3.49)	9.03(3.89)
Respondents years of schooling	7.98(3.62)	8.38(3.62)	8.28***(3.62)	7.79***(3.94)	9.65***(3.15)	9.33***(3.36)
Livestock units [a]	1.91(2.7)	1.88(2.0)	1.88***(2.17)	5.08(4.03)	4.2(3.99)	4.35***(4.03)
Village market (yes=1, 0 otherwise)	0.61*** (0.49)		0.77(0.45)	0.77(0.43)	0.76(0.43)	0.76(0.43)

Source: Survey results. Note: standard errors are in parentheses , [a] denotes the livestock equivalent units were based on weighted sum for cattle (1), goat (0.4), sheep (0.4) and pig (0.4). asterisk ***, **, *denotes significance of group mean differences) at the 1, 5 and 1% level respectively. [NB] the respective proportion of male respondents in our choice experiments in female and male headed households.

RPL model is a better fit for the estimation of the data.

Another consideration in the econometric estimation was to test for the heterogeneity in farmer preferences for bean variety attributes between the two provinces, representing distinct bean production environments. The overall fit of the models (McFadden's ρ^2) for pooled sample, Eastern and Western Kenya study sites are relatively high. The Alternative specific constant (ASC) that captures the effects on utility of any attributes not included in choice specific attributes for the pooled sample is positive but insignificant. However, the ASC for the Eastern sample is positive and significant, indicating that farmers located in this production context, mainly characterized by drought stress, prefer a change to status quo, that is, they prefer an environmental stress tolerant variety to traditional varieties currently grown. However, ASC is negative and insignificant for Western province sample.

All included attributes are significant determinants of choice in the pooled sample and Eastern Kenya, but taste better attribute had a positive but insignificant effect on the choices of respondents based in Western Kenya. Generally, farmers derive higher utility from better tasting and short time cooking attributes for beans. The results also indicate that the magnitude of the ranking for the choice options with high tolerance to environmental stresses (drought /disease) is higher in Eastern Kenya than in Western province. This means that environmental stress are more pressing for farmers in Eastern Kenya where susceptible crops like beans are at constant risk of drought occurrence (Katungi et al., 2010).

The significance of the standard deviation is a sign of preferences heterogeneity among respondents' for attributes: yield, tolerance to environmental stresses (that is, drought and disease pressure) and short cooking time. However, when data is disaggregated by province, heterogeneity for yield and tolerance to environmental stresses becomes insignificant in the model for Eastern province, implying that farmers' preferences for these attributes in this location are homogenous.

Exploring sources of heterogeneity

Turning to exploring the sources of preference heterogeneity, Table 5 shows interesting results. Socioeconomic characteristics were introduced into the models as interactions, similar to the common format of the choice studies, allowing for convenient interpretations of the resulting coefficients. The socioeconomic characteristics *(for model specifications*) used, after testing for correlations and multi-collinearity problems, include: gender of the respondent (*gender,* 1=male), regional location *(province*, 1=eastern), household size (*hhsize*), land acreage (*land*), market access in the village (*market, 1=yes*), and per capita livestock units (*livepcap*), a proxy for agricultural wealth.

It is worth mentioning here that considerable variation remains (still significant standard deviations) after taking into account these socio-

Table 4. Coefficient estimates of random parameter logit model.

Variables	Pooled sample		Eastern Kenya		Western Kenya	
	Coeff.	Coeff. Std	Coeff.	Coeff. Std	Coeff.	Coeff. Std
ASC	0.113 (0.122)		0.407**(0.175)		-0106(0.179)	
Yield	0.177***(0.010)	0.055**(0.016)	0.189***(0.014)	0.013(0.077)	0.176***(0.014)	0.089*** (0.018)
Mattime	-0.021***(0.003)	-	-0.024***(0.004)	-	-0.018***(0.004)	
Tolerance	0.036***(0.002)	0.019***(0.002)	0.045***(0.003)	0.001(0.014)	0.028***(0.003)	0.028***(0.003)
Tastebetter	0.159***(0.053)	-	0.258***(0.079)	-	0.063(0.076)	-
Tastebad	-0.612***(0.055)	-	-0.882***(0.082)	-	-0.382***(0.078)	-
Cookshort	0.261***(0.052)	0.317***(0.063)	0.257(0.077)	0.235**(0.110)	0.309***(0.076)	0.323***(0.094)
Cooklong	-0.287***(0.052)	-	-0.279***(0.075)	-	-0.322***(0.074)	-
Price	-0.008***(0.003)	-	-0.012***(0.004)	-	-0.007*(0.004)	-
Log likelihood (LL)	-2286.64		-1040.97		-1196.91	
McFadden's ρ^2	0.302		0.363		0.271	
N	2982		1488		1494	

P*< 0.1, P** <0.05, P ***<0.01. The authors used simulations with 100 Halton draws for estimating the random parameters. ASC is the alternative specific constant, which is equalled to 1 if either alternatives A or B was chosen and 0 if the respondent chooses the status quo (alternative C).

Table 5. Coefficient estimates of random parameter logit model with conditional heterogeneity.

Variables	Pooled sample		Eastern Kenya		Western Kenya	
	Coeff.	Coeff. Std	Coeff.	Coeff. Std	Coeff.	Coeff. Std
ASC	0.095 (0.122)		0.395**(0.176)		-0.121(0.178)	
Yield	0.139***(0.022)	0.045***(0.017)	0.194***(0.036)	0.001(0.093)	0.105***(0.016)	0.076***(0.018)
Mattime	-0.020***(0.003)		-0.023***(0.004)		-0.017***(0.004)	
Tolerance	0.028***(0.005)	0.016***(0.002)	0.044***(0.003)	0.002(0.011)	0.021***(0.004)	0.025***(0.003)
Tastebetter	0.154***(0.053)		0.257***(0.077)		0.054(0.075)	
Tastebad	-0.594***(0.054)		-0.865***(0.079)		-0.363***(0.077)	
Cookshort	0.556***(0.112)	0.248***(0.072)	0.507***(0.088)	0.161(0.145)	0.669***(0.085)	0.253**(0.104)
Cooklong	-0.280***(0.052)		-0.269***(0.074)		-0.319***(0.074)	
Price	-0.008***(0.003)		-0.011***(0.004)		-0.007*(0.004)	
Yield*gender	0.050***(0.014)		0.061***(0.019)		0.044**(0.022)	
Yield*hhsize	-		-0.002*(0.001)		0.002*(0.001)	
Yield*livepcap	-		-		0.075*(0.040)	
Tolerance*gender	0.010***(0.003)		-		0.018***(0.005)	
Torelance*province	0.007***(0.003)		-		-	
Tolerance*land	-0.003**(0.001)		-0.003**(0.001)		-	

Table 5. Contd.

Tolerance*market	-	-	-0.010*(0.006)
Cookshort*gender	0.187***(0.068)	0.263***(0.097)	-
Cookshort*market	-0.203***(0.077)	-0.244**(0.112)	-0.188*(0.110)
Cookshort*hhsize	-0.022***(0.008)	-	-0.023**(0.010)
LL	-2240.82	-1015.93	-1170.54
McFadden's ρ^2	0.313	0.376	0.284
N	2982	1488	1494

Note: P*<0.1, P **<0.05, P ***<0.01. The authors used simulations with 100 Halton draws for estimating the random parameters. – represents insignificant values. ASC=Alternative Specific constant.

demographic characteristics of the respondent, indicating that preferences vary more than what is explained by those three socio-demographic characteristics of the respondent.

Generally, results reveal that differences among farm households in terms of their production context, household size, wealth assets (represented by livestock and landholding endowments), as well as market access do influence farmer's valuation of bean variety attributes. The demand for environmental adaptability varies across locations, with farmers in Eastern province, who face considerably higher variations in weather conditions, deriving higher value from bean varieties with higher tolerance to environmental stresses than those in Western parts of Kenya. This is similar to the findings of the study by Lapar and Ehui (2004) in Philippines that regional location plays a critical role in the adoption of dual-purpose forages, and they suggested that targeting farmers in areas with environmental stresses such as soil degradation and shrinking grazing areas would be paramount.

Our results also show that households withlarger landholdings and those with higher per capita livestock units give more weight to productivity attributes than to environmental and yield stability attributes. This result could be interpreted to mean that farmers with more agriculture wealth have a higher capacity to absorb risk and are looking for bean varieties with higher returns to their inputs. On the other hand, farmers with smaller land acreages derive higher values from the bean varieties with higher tolerance attributes. This result is very intuitive in that smaller farm households are more risk averse and require crop varieties that reduce risk vulnerability in terms of stable yields. These results are similar to those reported by Lapar and Ehui (2004) and Asrat et al. (2009).

Heterogeneity in men and women preferences

also emerged in case of yield, tolerance to environmental stresses and reduced cooking time attributes but there are some variations between the two production contexts. Across all the study sites, male respondents derive higher values from high yielding bean varieties than their female counterparts because of their direct role in the household economic standing, culturally delegated to men. Since the profitability of beans as an enterprise is strongly positively correlated with yield (Katungi et al., 2011b), men are expected to attach more importance to the yield attribute than women. Comparatively, the magnitude of the coefficients is larger for Eastern province because current yields are lower in these areas due to drought severity.

The interaction between gender and short cooking time was also positive but only significant for Eastern province. This contrasts the long standing assertion that short time cooking, an attribute for post-harvest is a preference for women because of their positions in the food chain (Ngwira and Mwangwela at http://eastafricacrsp.wsu.edu; Farnworth and Jiggins, 2003). This result can be explained by the fact that in Kenya, fuel wood is mainly generated from farm trees, which have multiple competing uses (such as building materials or income forgone from sales) controlled by men and because trees grow slowly in low rainfall than in high rainfall areas, the opportunity cost of trees used on wood fuel is higher in drought prone area. Besides, the opportunity cost of waiting at home while bean is cooking may be higher for men than it is for women.

Household size and market access also have significant influence on the preference for bean variety attributes. Small-sized households in both Eastern and Western Kenya derive higher utility from short time cooking varieties. This is because per person cost of cooking is likely to be higher when household size is small than when it is large. Household size shows significant but opposite effects on the utility derived from higher yielding bean varieties in the two provinces. It is positive for western Kenya, which is interpreted to mean that potential adopters in Western Kenya need varieties that will provide higher yields to feed their large-sized households. On the other hand, the negative effect of household size for Eastern province was surprising and this requires additional data to explore further why household size might negatively influence preferences for higher productivity.

Finally, the interaction between market access and short cooking time attribute in both provinces as well as between market access and tolerance to environmental stress attribute in Western Kenya are negative, indicating that households with no access to market in their respective villages are more likely to adopt bean varieties with such improvements. Those with better access to market may be able to obtain such varieties at fair transaction costs.

Willingness to pay and heterogeneity between female and male headed households

We used mean values in Table 3 for some selected variables to estimate farmers' marginal willingness to pay (WTP) a premium (positive WTP values) or a discount (negative WTP values) for a given attribute as shown in Table 6.

In general, farmers are willing to pay higher premiums for short time cooking, better taste, high yielding, and tolerance to environmental stresses attributes, but they need price discounts to compensate for their loss in utility, if the proposed bean variety has a worse taste, requires more days to mature, and takes longer to cook than the current varieties. For instance, farmers in Eastern Kenya are willing to pay price increases of approximately 47% and 82% for better tasting and short cooking varieties, respectively. In contrast, the current seed price of beans per kilo has to reduce by over 150% and about 50% for bad tasting and long-time cooking varieties (compared to the status quo) to be accepted among farmers in Eastern Kenya, respectively.

Differences between provinces emerged from the analysis for the three random attributes (that is, yield, tolerance to environmental stresses and short cooking time). Farmers in Western province were willing to pay higher premiums for yield and short time cooking attributes than their counterparts in the Eastern province, perhaps because of their market orientated production.

To assess whether there are significant differences between the WTP values between female and male headed households (Poe et al., 1994), simple convolutions process was undertaken (Rolfe and Windle, 2005). After having calculated the WTP, differences between WTP values were calculated by taking one vector of WTP from another. The 95% confidence interval is approximated by identifying the proportion of the differences that are different from zero (Table 6). The tests show that the implicit prices are significantly different between male and female headed households for some of (or all) the random attributes in a pooled sample and Eastern Kenya, but none in Western Kenya. Male headed households are willing to pay more for both high yielding and environmental tolerant varieties at pooled sample level, while at province level only male headed households in Eastern Kenya are willing to pay more, in addition to the above two attributes, for varieties that take short to cook compared to the female headed households.

Conclusions and implications

Important bean variety attributes have been well established using qualitative methods but studies that use quantitative methods to quantify farmer valuation of those attributes are still few. This study used a choice experiment approach to assess valuation of bean variety attributes, heterogeneity in farmer valuation of such attributes and investigate differences in gender preferences --under drought stress and disease production environments of Kenya.

Consistent with the existing literature, results reveal that all production and consumption bean variety attributes included in the analysis, are important determinants of variety choice. However, farmers who are also consumers, attach higher weights to consumption and post-harvest processing attributes than production attributes. Taste is valued highest followed by reduced cooking time. This implies that though research has considerably improved on these attributes, embedded in new improved varieties, there is still demand for further reduction in cooking time, demonstrated by higher WTP even in western parts of Kenya where these varieties have been successfully adopted. Moreover, few farmers have adopted the improved varieties which could be constrained by poor access to improved variety seed. Similarly, results reveal that farmers will require higher compensation if new bean varieties exhibit reduced taste and/or take longer to cook than the existing ones. Therefore, breeders should take maximum precautions to avoid any alterations in these attributes that will result in a reduction in taste and/or increase in the time required to cook new varieties relative to the existing ones. Both results can be attributed to the diminishing access to resources such as fuel wood as land gets scarcer and slower adoption of alternative cooking energy options such as electricity or gas.

The study findings indicate significant heterogeneity in farmers' preferences across and within each production

Table 6. Marginal WTP for bean attributes (95% confidence interval) and proportion of WTP different than zero.

Attribute levels	WTP estimates			Proportion of
	Average	Female	Male	Fem. vs. Male
		Pooled sample		
Yield	20.75(5.74 – 35.76)	19.23(5.22 – 33.24**)**	21.12 (5.86 – 36.37)	0.97*
Mat time	-2.55(-4.49 – -0.611)	-2.55(-4.49 – -0.611)	-2.55(-4.49 – -0.611)	na[b]
Tolerance	4.29(1.04 – 7.52)	3.92(0.91 – 6.94)	4.38 (1.07 – 7.69)	0.98*
Taste better	39.88(4.27 – 84.03)	39.88(4.27 – 84.03)	39.88(4.27 – 84.03)	na
Taste bad	-153.08 (-272.23 – -33.94)	-153.08 (-272.23 – -33.94)	-153.08 (-272.23 – -33.94)	na
Cook short	70.37(22.38 – 118.37)	63.55(18.86 – 108.24)	71.71 (22.85 – 120.26)	0.82
Cook long	-72.29 (-127.34 – -17.24)	-72.29 (-127.34 – -17.24)	-72.29 (-127.34 – -17.24)	na
		Eastern Kenya		
Yield	18.52(5.18 – 31.88)	16.81(4.55 – 29.08)	18.88(5.30 – 32.47)	0.96*
Mat time	-2.13(-3.80 – -0.46)	-2.13(-3.80 – -0.46)	-2.13(-3.80 – -0.46)	na
Tolerance	3.70(0.74 – 6.66)	3.67 (0.73 – 6.62)	3.71 (0.75 – 6.67)	0.93*
Taste better	46.84(1.56 – 95.25)	46.84(1.56 – 95.25)	46.84(1.56 – 95.25)	na
Taste bad	-157.29 (-279.24 – -35.35)	-157.29 (-279.24 – -35.35)	-157.29 (-279.24 – -35.35)	na
Cook short	82.13(8.82 – 155.44)	65.13(1.10 – 131.36)	85.25(10.34 – 160.16)	0.96*
Cook long	-48.97(-91.12 – -6.82)	-48.97(-91.12 – -6.82)	-48.97(-91.12 – -6.82)	na
		Western Kenya		
Yield	22.88(-3.95 – 49.65)	21.82(-3.80 – 47.45)	23.13(-4.00 – 50.27)	0.79
Mat time	-[a]	-	-	na
Tolerance	-	-	-	na
Taste better	-	-	-	na
Taste bad	-	-	-	na
Cook short	85.20(-10.23 – 180.64)	95.21(-10.54 – 200.97)	82.20(-10.35 – 174.75)	0.83
Cook long	-	-	-	na

Notes: farmers' valuation of bean attributes were calculated with the Delta method of the Wald procedure contained within the LIMDEP 9.0 NLOGIT 4.0. Numbers represent the percentage change in total price per kilogram of beans. Effect-coded variables were multiplied by 2 before division with price coefficient. P*<0.1 [a] – Represents insignificant values. [b] na indicates for fixed parameters (that is, mat time, taste better, taste bad, and cook long), no proportions were calculated.

context. Farmer preferences were found to be heterogeneous for yield, tolerance to environmental stresses and reduced cooking time and this heterogeneity is partly explained by differences in gender and household characteristics in terms of physical assets (livestock and landholdings), household size and market access. For example, household endowed with more land and livestock as well as larger sized households attach higher weights to higher yielding bean varieties than their counterparts. Likewise, bean varieties with reduced cooking time attributes are less valued by larger-sized households and those with better access to markets while men attach higher values compared to women.

Differences between men and women preferences depend on the attribute in question and production context. Men and women preferences for yield were found to diverge under both conditions of drought and severe disease infestations, with men deriving higher values from high yielding bean varieties than women respondents. On the other hand, differences in men and women preferences for the short cooking time varieties and those that are tolerant to environmental stresses depend on the empirical context. Under severe conditions of drought, men and women preferences for drought tolerance were found to converge but diverged under moderate disease stress conditions of western Kenya. The study findings were surprising in case of reduced cooking time. Results indicated that men and women preferences for reduced cooking time diverge under drought stresses of Kenya but converge under high rainfall conditions of Kenya.

Overall, the study findings indicate that Kenyan bean producers, though resource constrained, are on average willing to pay additional cost in terms of higher seed prices to access varieties that are higher yielding and those with reduced cooking time but a big discount in price will be required for any deterioration in taste or extended cooking time. While this analysis sheds light on the implicit price, further investigations that apply hedonic price modeling to bring out the contribution of each attribute to the market price of seed would assist in pricing of specific varieties. The higher willingness to pay by male headed households to improvements in yield, and post-harvest processing of beans indicate that women may be constrained by poor access to resources and have lower ability to pay. The result could also imply that men are less satisfied with the current levels of these attributes and explains why common bean in Kenya has remained a women dominated crop.

These results have important implications for contextual variety development, breeding priority setting, and targeted dissemination of improved varieties as well as gender mainstreaming in bean improvement for Kenya. First, for varietal adaption to environmental stresses considered in this paper, results suggest that the impact will be higher if breeding simultaneously increases yield and consumption attributes. Where possible, breeders should strive to increase the levels of these attributes; while increasing tolerance to environmental stresses. This would increase demand of such varieties, speeding up their adoption. Our results are comparable to the findings of Sall et al. (2000), who suggested that improved rice varieties with similar characteristics as the local rice land races in terms of production and consumption qualities such as crop cycle length, cooking quality, etc would likely be adopted by farmers. However, it should be noted that the current participatory variety selection procedures are unable to evaluate taste and cooking time before variety release since these attributes are invisible. Hence, breeder should consider including these steps in the variety evaluation process as this will enable release of varieties with desirable taste and cooking time, which in turn would increase adoption of improved varieties.

Second, breeding should target to meet the needs of different types of farm households classified according to resource endowments, and risk preferences. Thirdly, information dissemination alongside bean seed varieties should take into consideration the differences among farm households with the aim of reaching farmers in an inclusive way.

The final implication is related to gender. The higher values derived by men compared to women from improvements in bean yield and reduced cooking time points to the possibility that once the research is successfully completed, men would be attracted to bean production and could take it over from women, with possible negative consequences. Hence, there is need to adopt approaches and strategies that integrate gender differences and constraints to minimize the possibility of undesirable gender impacts of research that seeks to increases yield, tolerance and stability of common bean in Kenya.

Conflict of Interest

The authors have not declared any conflict of interest.

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