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Varietal characteristics of cassava: farmers' percep-tions and preferences in the semi arid zone of West Africa

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Abstract. The study examines and models farmers' perceptions and preferences of cassava varietal characteristics vis-à-vis the decision to adopt cassava cultivars in their fields. The paper is built on the concept of effect of technology specific factors on adoption. By way of threshold decision modeling for each of the countries considered, the results reveal different scenario. Based on the varietal characteristics considered, environmental resistance quality (ERQ), high yielding quality (HYQ), early maturing qualities (EMQ), leaf quality (LQ), inground storability quality (ISQ) and taste quality (TQ) have declining importance in the order of listing. As such, environmental resistance quality appears a major varietal characteristic that the farmers perceived and preferred for cultivating any cassava cultivar in the zone. The results therefore reinforce the relative importance of varietal characteristics in choice and preference of cassava cultivars by farmers. It is therefore imperative for breeders to develop cultivars that will be acceptable to the farmers considering their level of preference and perceptions.

Introduction

Cassava (*Manihot esculenta* Crantz) has become a major source of food and income for smallholder farmers and of raw materials for industries (Okigbo, 1980; Ramanoff and Lynam, 1992 and Sanni et al, 1998). It is also of sufficient importance for livestock feeding. Of the more than 200 million people in Sub-Saharan Africa, about one third of the population, get more than half their calories from foods made from cassava. Trends in cassava production have indicated a steady growth over time. In West Africa, the major cassava-growing area, a rate of 4.4% was recorded between 1976 and 1998 (FAO, 2000). About two-thirds of that increase was estimated to be due to the expansion of the area cultivated, while the remaining one third was the result of increase yields from new improved varieties (Manyong et al, 2000).

Cassava as a staple food in the Sub-Saharan Africa is playing a major role in alleviating food crises experienced in the region (Inaizumi 1997) and is widely accepted. The wide acceptability of cassava is attributed to its efficient production of food energy, year-round availability, tolerance to extreme stress conditions and suitability for peasant farming and food systems in Africa (Hahn and Keyser, 1985; Hahn et al. 1987).

Practically, the commendable success of cassava as a choice staple root crop by farmers within the sub-region can be largely attributed to the development of varieties with improved characteristics for Africa's agro ecologies. Breeding programs headed by IITA/CIAT over the past 3 decades have resulted in production of several 'elite' genotypes that have resistance to (CAD) and (CBB) as well as high, stable yields and good consumer acceptability (IITA, 1992). These improved traits which include resistance to virus disease, high yield of tubers, reduced HCN content, early maturity, drought resistance, improved taste quality, adaptability, and delayed perishability of fresh roots, etc (Pursglove, 1968, Otoo and Hahn, 1987, Ikpi, 1988) affect the decision of farmers to cultivate these cultivars in different ways and intensity.

The introduction and subsequent cultivation of cassava in the semi arid zone of Central and West Africa is more recent than in the humid and semi-humid zones. The semi arid zone is characteristically the cereal belt of Africa and majority of the farmers subsistent on cereals. Therefore, the farmers' acceptance of cassava as an emerging staple food is understandably due to the farmers' perception of cassava importance to their food and income needs. Basically, allocation of farmland for cassava cultivation (either as sole or mixed) involves opportunity cost to other primary staples that are traditional to the zone. A rational thinking farmer therefore, will allocate his scarce resource to cassava production if its utility exceeds the utility of traditional staples. But, the expected utility of cassava defined in terms of high income and better food is explained by the varietal characteristics of cassava they cultivate or would like to cultivate.

Studies have shown that farmers' have subjective preferences for crop varietal characteristics and these significantly conditioned adoption decision of the crops (Edwin, 1994; Adesina and Zinnah, 1992). As such, farmers' perception of crop varietal characteristics exerts strong influences on farmers' adoption of such crop. Certain cassava cultivars are predominantly cultivated in specific areas and farmers' preferences are based on certain varietal characteristics. These characteristics affect farmers' perceptions and the dynamics of adoption of cassava varieties. It is therefore empirically relevant to evaluate the probability of cassava adoption as conditioned by the varietal characteristics. Such information is necessary as their exclusion from adoption model may introduce bias in the results of factors determining adoption decision (Adesina and Zinnah, 1992).

An empirical assessment of the probability of farmers cultivating certain cassava cultivars, given their respective inherent characteristics, would definitely strengthen research efforts, extension service to enhance adoption, diffusion, and increased production of cassava in the semiarid zone of West Africa, where a large food gap already exists.

Characterization of cassava cultivars. Cassava cultivars with about 110 different names are currently grown in the semiarid zone of West Africa. The highest number of cultivars (35) was reported in Burkina Faso while the lowest (19) was reported in Ghana and Nigeria (Tshiunza et al., 1999). It was also reported that 16% of cassava cultivars do not have individual names. The IITA has an extensive research activity on cassava and have developed cassava cultivars that have been adopted and diffused into villages in Sub-Saharan Africa. Based on the peculiarity of each cultivar farmers' use different local vernacular names to identify them.

Taking the varietal characteristics of the cassava cultivars into consideration, of the 110 different cultivars currently grown, about 2/3rds are drought tolerant and high yielding. Almost all cultivars are harvestable at 12 months or before. But about 35% of them are said to be harvestable at 6 months or before, mostly in Niger and Nigeria. Further, about thirty-seven percent of cassava cultivars could stay in the ground without deteriorating for about 12 months, while 47% for a period between 12 and 24 months and only 16 percent could stay beyond 24 months.

In addition, other varietal characteristics that give peculiarity to cassava cultivar is cyanide (HCN) content of cassava root and leaves, dry matter content (DMC) and cassava root yield. The level of DMC in cultivars varies between 32 and 45% whereas the harvest index ranges between 0.42 and 0.60. On the average, more than half of the cassava cultivars in the semiarid areas have low levels of HCN; only about 3 % have high levels of HCN in the roots. These varietal characteristics assist in the adoption process and social relevance of cassava crops in the semiarid region of West Africa.

Conceptual frame work

Farmer adoption decisions of technologies or crop varieties is adequately integrated to the theory of the threshold concept that explains and predicts dichotomous decisions and behavior. The threshold concept represents adoption as one, and zero for non-adoption. This creates a sensitive response in the decision variable, which can be observed only in the segment between the two extremes (Finney, 1952). Within these extremes technology is either preferred or not. But the adoption threshold for any agricultural technology is explained in some economic theories that actually detect the pattern of adoption.

Economic literature identified three possible directions, which adoption theory might take over time. These are the innovation - diffusion theory, the economic-constraints theory and the technology characteristics – user's context theory. Rogers (1962) initiated the innovation-diffusion theory. Accordingly, the theory holds that a technology is transferred from its source (research system) to final users through agent – medium (extension systems) and its diffusion in potential users – communities depends mainly on the personal characteristics of the users. It therefore follows that effective communication is requite for technology transfer and inappropriate communication hinders technology diffusion (Negatu and Parikh, 1999). Innovation-Diffusion theory assume that a new technology has been already adopted, but those who have adopted have not yet used the best practice fully to achieve the full potential of the technology (Kalirajan and Shand, 2001). In the case of economic-constraints theory, Aiken et al. (1975) contended that economic constraints reflected in asymmetric distribution pattern of resource endowments are the major determinants of observed adoption behavior (Adesina and Zinnah, 1993). The theory further assumes that market prices (or surrogate prices induced by policy and institutions interventions) reflect the relative scarcity of factors implying the existence of (or need for) well performing markets and the importance of price policies (Hayami and Rutman, 1985).

The technology characteristics- users context theory integrates approaches, which assume characteristics of a technology underlying users' agro-ecological, socio-economic and institutional contexts, which play the central role in the adoption of decision and diffusion process (Biggs, 1990). This theory further explains the perception of potential adopter regarding the characteristics of a technology as a component affecting adoption decisions hence the diffusion of technology (Gould et al, 1989). This theory identifies the importance of farmers' involvement in the technologies with appropriate and acceptable characteristics, and also implicitly recognizes the importance of institutionalization of research policies and strategies that facilitates the participation of farmers' and other relevant stakeholders in the technology development process (Negatu and Parikh, 1999; Bats et al, 1999).

This study recognizes the theory of technology characteristics. It is on the assumption that the factors which constitute technology characteristics collectively convey into a single response threshold, which makes the sum of these independently random variables to be asymptotically normal. But a distribution of thresholds within a random sample would be expected because of individual differences as expressed in respective factor. We therefore expect functional relationship of the threshold decision model with a normal sigmoid curve (Yamane, 1960), and applications of qualitative choice models would explain the functional relationships, which is probabilistic in nature.

However, the concept of farmers' adoption decisions of improved technologies is built on the assumption of expected utility that would be maximized if the probability of adoption were one (Rahm &Huffman, 1984). Therefore, the probability that a farmer adopts a new technology is a function of the expected utility (benefits) derivable from the decision to adopt. But, there is a functional relationship between expected utility (benefit) of a technology and its characteristics, expressed as:

$$YN = 1 \text{ if } E(UN) > E(UT) \quad (1)$$

$$P(YN) = f\{E(UN)/E(UT)\} \quad (2), \text{ and}$$

$$E(U) = F(TC) \quad (3)$$

where: YN = 1 is adoption of new technology

E (UN) = Expected utility of new technology

E (UT) = Expected utility of old technology

TC = technology – specific characteristics

The adoption function is unobserved, as in the case of utility function but specifically relates with vector of observable factors that can be grouped as technology – specific characteristics i.e. the varietal characteristics. By assuming a non-stochastic, but linear function, we may have an adoption function implicitly represented as:

$$A_{ij} = \alpha_i A_j(TC_i) + e_{ji} \quad j = 1, 2;\ i = 1, 2, \ldots n \quad (4)$$

Where TC_i represents vector of Technology specific characteristics. Equation (4) holds for preference of the farmers for the adoption. The perception of farmers for a given new technology is measured on the ordinal scale being determined by various explanatory factors. These factors are the determinants of adoption.

Literatures are awash with adoption – diffusion studies many of these literatures identified farmers- and farm specific factors or other institutional factors as major determinants of adoption behavior of farmers (Jones, 1967; Shakya and Flinn, 1985; Feder et al, 1985; Osuntogun et al, 1986; Voh, 1982; and Kebede, et al. 1990). With regards to effect of technology specific factors on adoption decision see Agarwal (1985); and Adesina and Zinnah (1992). However, in all the adoption studies, specifying the probability of adoption is a vector of unknown parameters. The explanatory variables are chosen based on the underlying agricultural technology adoption theory.

Model Specification

The empirical model specifies the adoption as a function of technology specific factors. Basically, econometric modeling of adoption function is necessary to estimate parameters of a threshold decision model. This is accomplished by applications of qualitative choice models in explaining different socio-economic phenomena. In this study, we hypothesized multivariate threshold decision models of standard cumulative distribution function (Probit) and the logistic distribution functions (logit). As in the case for multivariate dichotomous an aggregate variable, say A is assumed such that A is a linear combination of the adoption – induced variables, with A^* as threshold playing the role of disturbance force. With this, the disturbance term is therefore homoscedastic in both probit and logit approaches (Goldberger, 1964). Specifically, the multivariate probit model was formulated as follows to estimate the parameters involved in these relationships:

$$Y_i = \begin{cases} 0, \text{ if } A_i < A_i^* \\ 1, \text{ if } A_i \geq A^* \text{ for all i,} \end{cases} \quad i = 1, 2 \dots n \text{ observations} \quad (6)$$

Where Y_i is the probability that the farmer chooses to plant cassava either as sole or mixed with other crops; and

$$Ai = \beta_1 ERQ + \beta_2 HYQ + \beta_3 EMQ + \beta_4 ISQ + \beta_5 LQ + \beta_6 TQ \quad (7)$$

A_i^* = the threshold level (latent variable) which is not observable.

The logit model was specified as follows:

$$Y_i = 1/\ 1 + e^{-f(Ai)} \quad (8)$$

where Y_i and A_i are as given in equations (6) and (7). Following close association of both probit and logit models, the change in the probability that the farmer cultivate cassava in his farm given a change in any one of the adoption induced variables can be computed as : $\delta Y_{i/} \delta A_i = f(w_i)^{\beta}$ (9)

where $f(w_i)$ is the standard normal density (logistic density) function for the logit model.

Selection of the 'best' or most appropriate model among probit and logit involved evaluating the statistical estimates. This includes observing how consistent the signs of the coefficients are with hypothesized relationships, and the tests of significance. Amemoya (1981) identified difficulty involved in selecting between the two models because of the statistical similarities between the two models. On this premise, our choice of any one model was not dominant, but done after each estimation. Both the probit and logit models were estimated through an iterative maximum likelihood procedure (White, 1978).

Definition of variables in the model:

ERQ = Environmental resistant quality: This is a composite variable that represents the ability of cultivar to withstand drought, wind, harmattan and heat. It is a discrete variable: ERQ = 1 for resistance and ERQ = 0 for non-resistance

HYQ = High yielding quality: HYQ = 1 if the cultivar gives higher yield than local variety in terms of the cassava tuber and HYO = 0 otherwise.

EMQ = Early maturing quality: EMQ = 1 for early maturing quality; and 0 otherwise

ISQ = In ground storability quality: ISQ = 1 for high in ground storability quality, 0 otherwise.

LQ = Leaf quality, a discrete variable that is 1 if the cultivar leaves are good for human consumption and 0 otherwise.

TQ = Taste quality: It is discrete variable; TQ = 1 if a cultivar Q chosen because of perceived good taste and TQ = 0 otherwise.

Data and method of collection

Date were from a village-level survey collected through the collaborative study on cassava in semiarid Africa (COSCASA) project in 1998. Data were collected countries within the semiarid area of West Africa. These were as follows: Burkina Faso, Ghana, Chad, Niger republic and Nigeria. For Nigeria, data were collected only from the semi-arid part in the north of the country. Each country's map was generated using Microsoft Qbasic Software and subdivided into a grid of cells of 10° latitude by 10° longitudes. The target area was then delineated to form a sampling frame from which 40 grid cells were randomly selected. Grid cells that fell into uninhabitable land were excluded and replaced with those nearest. In each selected cell, a list of villages was compiled with the assistance of national collaborators and one village was randomly selected. In all, 200 villages were randomly selected for the study, thus 40 villages per country. Details of the sample selection approach and names of selected villages and description of database are found in Okechukwu et al. (1999).

Results and Discussion

The empirical results for both the probit and logit models as to the extent to which the varietal characteristics influence or determine the cultivation of the most ranked cultivars for each of the country and the whole region are summarized in Table 1 and Table 2. A maximum of 20 iterations was required for convergence of the probit and logit model respectively. The chi-square statistic indicate that the models, as specified for each of the country, explained significant non-zero variations in the varietal characteristics as factors affecting farmers' cassava adoption decision. For the fact that neither model specification dominates the other on purely statistical grounds in explaining farmers' adoption decision, both specifications appear valid and would be simultaneously used in the discussion. But on a more specific way the probit model yielded more parameter estimates that are asymptotically efficient and consistent then logit model for all the countries.

Table 1. Probit analysis of 6 varietal characteristics influencing adoption of cassava cultivation in 5 countries in semiarid West Africa

Variables	Burkina Faso	Chad	Ghana	Niger	Nigeria	Whole region
Taste Quality (TQ)	0.215	0.228	0.006	0.315	0.450**	0.007
	(0.381)	(0.462)	(0.192)	(0.481)	(0.224)	(0.074)
Inground Storability Quality (ISQ)	0.002	0.507	0.305	0.102	0.699***	0.125
	(0.297)	(0.220)	(0.267)	(0.397)	(0.225)	(0.084)
Leaf Quality (LQ)	0.346	0.330	0.260	-0.446	0.417	0.021
	(0.363)	(0.766)	(0.241)	(0.463)	(0.263)	(0.089)
High Yielding Quality (HYQ)	0.572*	0.190	0.743***	0.672	0.244	0.159**
	(0.110)	(0.606)	(0.259)	(0.393)	(0.216)	(0.077)
Early Maturing Quality (EMQ)	0.110	-0.343	0.345*	0.210	-0.463*	0.153*
	(0.297)	(0.848)	(0.207)	(0.397)	(0.266)	(0.080)
Environmental Resistant Quality (ERQ)	0.618**	1.237*	0.466**	0.548**	0.587**	0.172**
	(0.306)	(0.6650)	(0.225)	(0.206)	(0.255)	(0.082)
Constant Term	2.423***	-5.323***	-3.347***	-3.423***	-3.048***	-2.975***
	(0.314)	(0.827)	(0.525)	(0.214)	(0.406)	(0.101)
Model ÷2	51.004*	51.799**	65.161***	71.044*	89.32***	855.3***

Note: significant levels: ***(1%), **(5%) and *(10%). Values in the parentheses are standard errors

Taste quality (TQ). Taste quality appears to be a significant predicator of farmers' decision to select for specific cassava cultivars in Nigeria only. With a coefficient of 0.450, P< 0.05 for probit model and 0.878, P< 0.1 for logit model there is likelihood and high probability of cultivating cassava cultivars due to the perceived high taste quality associated with those cultivars. Not minding the non-significance of the estimated coefficient for other countries, the probability of planting cassava would be high when the farmers are sure of good taste quality of cassava cultivars, especially when the farmers' interest are in the fresh roots that are boiled for consumption.

In ground storability quality (ISQ). From the results of logit analysis, the ability of a cassava cultivar to store for longer period after maturity, being a major varietal characteristic is a major adoption shifter for Chad Republic and Nigeria. As such, the probabilities of adopting cassava cultivar increase as its inground storage ability increases for both Chad and Nigeria. A probability for farmers to adopt cassava with good in ground storability (store for longer months in the ground after maturity) is 1.409, p<0.01 for Nigeria and 1.218, p<0.05 for Chad. Farmers producing cassava where post-harvest technology is lacking would want to produce small marketable surpluses to check price fluctuation and by this would prefer those cultivars that can store longer in the ground. This would ensure they have constant supply for longer period before next harvest year. Good ISQ also ensures that the farmer has a continuous stream of income from cassava, as cassava is harvested when cash is required.

Leaf Quality (LQ). The perceived high leaf quality as a good varietal characteristic is a major adoption shifter in both Chad and Nigeria. This is as revealed in the probit model. In Chad, the perceived high leaf quality increased the likelihood of adoption by about 50%. In the same vein, the likelihood of adoption increased by about 69% in Nigeria. These results are points to the utilization of cassava leaves for human food and/or livestock feed. As such, farmers could readily integrate the cassava cultivars that have high leaf quality into their farms.

High yielding quality (HYQ). Expectedly, this quality appears to be a significant predicator of cultivating certain cassava cultivars in the region. Interestingly, both the results of probit and logit analyses agree on the pattern of significance. This quality is a higher adoption shifter in Burkina Faso (1.2749, p< 0.1), in Ghana (1.09003, p<0.05) and in Niger (1.3528 p<0.05) from the result of logit analysis. Beside these, the coefficient of this quality for the whole region indicates the existence of increase probability (15 percent) of adopting cassava cultivars when the

Table 2. Logit analysis of 6 varietal characteristics influencing adoption of cassava cultivation in 5 countries in semiarid West Africa

Variables	Burkina Faso	Chad	Ghana	Niger	Nigeria	Whole region
Taste Quality (TQ)	0.545	0.128	0.091	0.645	0.878**	-0.019
	(0.971)	(0.207)	(0.437)	(0.871)	(0.481)	(0.202)
Inground Storability Quality (ISQ)	-0.074	1.218**	0.238	-0.174	1.409***	0.276
	(0.705)	(0.560)	(0.530)	(0.725)	(0.528)	(0.226)
Leaf Quality (LQ)	-0.757	0.156	0.267	-0.697	0.784	-0.016
	(0.873)	(0.319)	(0.520)	(0.863)	(0.598)	(0.238)
High Yielding Quality (HYQ)	1.275*	0.110	1.090**	1.355**	0.452	0.240
	(1.706)	(0.248)	(0.538)	(0.746)	(0.489)	(0.211)
Early Maturing Quality (EMQ)	0.070	-0.060	0.508	0.160	-1.076**	0.281
	(0.736)	(0.359)	(0.454)	(0.656)	(0.544)	(0.218)
Environmental Resistant Quality (ERQ)	1.449**	0.543**	0.729	1.559**	1.198**	0.241
	(0.744)	(0.264)	(0.496)	(0.644)	(0.548)	(0.219)
Constant Term	-4.771***	-2.762***	-5.420***	-4.961***	-5.699***	-5.791***
	(0.806)	(0.353)	(0.955)	(0.616)	(0.866)	(0.240)
Model ÷2	54.654***	49.969**	61.933**	64.654**	88.604***	699.835***

Note: significant levels: *(1%), **(5%) and *(10%); Values in the parentheses are standard errors**

farmers perceive the cultivars to possess high yielding ability, either in terms of root tuber or leaves (see probit result). Therefore, farmers' perceptions of cultivating cassava and their preferences of certain cultivars are greatly enhanced when they are aware of high yield or crop productivity per farmland.

Early maturing quality (EMQ). The knowledge of early maturing quality of certain cassava cultivars is significantly determining varietal factors of cassava adoption decision in Ghana (0.3452, $p < 0.1$), Nigeria (-0.463, $p < 0.1$), and the entire region (0.529, $p < 0.1$), using the probit result. There is therefore high likelihood of adoption of cassava, when the farmers are sure that the cassava cultivar they are cultivating would produce matured roots within shortest period of time. This is so considering the necessity of having cassava as emerging and reliable staple in the face of widespread hunger and poverty. However, the apparent wrong sign of negative for Nigeria case is quite peculiar. The most likely reason could be that since land is quite scare in Nigeria the farmers would prefer those cassava varieties that they can harvest within shortest period of time so as to used their land for cereal productions.

Environmental resistance quality (ERQ). As a composite variable, the ability of cassava cultivar to withstand drought or flooding, wind, harmattan, heat and other environmental hazards that characterized semiarid is assumable the most important adoption shifter in the region. This is confirmed with the signs and magnitudes of all the significant parameter estimates for all the countries. This therefore, implies that the farmers in this region would adopt cassava in their fields when they are sure that the cultivars to be planted will survive the haze environmental condition of the semiarid. This insures them against the perils of nature and eventual crop failures.

Conclusions

This study explicitly linked some varietal characteristics of cassava vis a vis the decision of farmers to adopt cassava cultivars in their field. The basic aim centered on quantitatively isolating the effects of technology specific factors, that is cassava varietal characteristics, on the decision to adopt cassava production in the semiarid zone of West Africa. By way of modeling, the estimation for each of the countries considered and the whole region adoption models reveal different scenario. From the result of probit analysis, the adoption models for Burkina Faso, Niger and Chad have two important adoption shifters each, while Ghana and the whole region models have three significant variables each. But the model for Nigeria appeared to have the highest significant factor coefficient (4). Further, from the variables considered, environmental resistant quality, high yielding quality, early maturing quality, leaf quality, inground storability quality and taste quality have declining importance in the order of listing. As such, environmental resistant quality appears to be a major varietal characteristic that determines cultivation of cassava cultivars. Taste quality is apparently the least important varietal characteristic within the farmers' perceptions. This may be linked with the fact that most of the cassava produced is consumed in processed forms (gari, fufu, flour) and not in the boiled form, for which taste would be important. In a specific term, though the findings reinforce the relative importance of varietal characteristics in determining the choice and preference of cassava cultivars, the results have revealed that the factors that affect the decision of farmers vary a cross the countries. Farmers' perceptions and preferences of varietal characteristic of cassava cultivars are quite crucial in research endeavor to identify and incorporate of varietal characteristics that meet farmers' preferences that would encourage the adoption of cassava in the semiarid region of West Africa.

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