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Farmer Preferences for Socioeconomic and Technical Interventions in Groundnut Production System in Niger: Conjoint and Ordered Probit Analyses

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ABSTRACT

Crop production decisions reflect preferences of farmers which are based on the structure of incentives and constraints that characterize agricultural systems. Therefore, an assessment of the intensities of farmer preferences for technical and socioeconomic interventions can provide useful guidance for the choice of appropriate strategies to improve productivity and incomes. Based on surveys conducted in groundnut-growing zones of Niger in West Africa, utilities of selected socioeconomic and technical interventions to farmers were derived through application of conjoint and ordered probit analyses. Across all regional and gender subgroups of respondents, groundnut farmers attach significant importance to access to credit and reliable markets for pods. The introduction of new and more productive varieties per se *would not significantly contribute to utilities of farmers at the present time. This possibly implies that until market and credit constraints are alleviated, farmers have lower utility for more productive varieties. Regional diversities were observed in the significance of utilities groundnut farmers can gain from the availability of local small-scale groundnut oil processing plant, fertilizer and changes to traditional rules governing access to land. There is no evidence of gender-based diversity in utilities and, therefore, prioritization of the interventions on the basis of observed utilities will benefit both gender components.* © *1997 Published by Elsevier Science Ltd*

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INTRODUCTION

Over the last three decades, groundnut (*Arachis hypogaea* L.) production in West Africa has declined in importance as a food and cash crop, both to farm households and national economies. Biophysical constraints, particularly drought, rosette virus attacks and aflatoxin contamination which affected groundnut production and exports (Oumarou *et al.*, 1990; Waliyar *et al.*, 1994) have contributed to the decline. However, ecological conditions are not the only factors guiding farmer choices and decisions in a production system (Dufumier, 1994). Economic and social conditions play important roles in farmer choice decisions. It would be pointless to promote crops or techniques that do not correspond to the true interests of farmers or for which the needed resources are unavailable (Dufumier, 1994). Therefore, the search for technical options, by international and national research institutes to alleviate biophysical constraints to groundnut production in West Africa, needs not only to consider socioeconomic factors when designing new technologies but also needs to be complemented with policies and programmes that alleviate socioeconomic constraints.

According to the literature, technology adoption can be constrained by credit (Krause *et al.*, 1990; Immink & Alarcon, 1993; Dufumier, 1994), land tenure (Yapa & Mayfield, 1978; Feder, 1985; Feder & Onchan, 1987; Roth *et al.*, 1993; Dufumier, 1994; Breman, 1995), lack of market access (Dufumier, 1994) and input supply (Dufumier, 1994). We hypothesize that interventions that resolve these socioeconomic constraints would provide greater utilities to groundnut producers in West Africa than the availability of a technical intervention, such as the introduction of new high-yielding varieties or fertilizer. The basis for this hypothesis is that during preliminary informal surveys, farmers consistently cited the socioeconomic constraints as very important to them. On the other hand, farmers rarely cited the need for technical interventions in the form of new high-yield varieties and fertilizer. We also hypothesize that diversities in utility of any socioeconomic and technical intervention will depend on regional peculiarities rather than gender component. This is because regional diversities in access to markets, agroecological and economic environment strongly influence relative profitability and desirability of investment in groundnut production by all gender types. The testing of these hypotheses requires information on intensities of farmer preferences for specified technical and socioeconomic interventions. This kind of empirical information at crop-level is rare for farming systems of West Africa. Yet, the information can provide essential guidance to the design of policies and programmes susceptible to facilitate technological change. The objective of this paper is to fill the gap in knowledge by providing the example of utilities of socioeconomic and technical interventions

mentioned in informal surveys by Nigerien groundnut farmers. This is achieved through the application of conjoint analysis to design parsimonious sets of attribute combinations used in surveys and ordered probit regression procedures to estimate indirect utilities.

THEORETICAL FRAMEWORK

Individual preferences for aspects of products or services motivate choice decisions. Where preference ordering of the defined services or products satisfies completeness, reflexitivity, transitivity and continuity axioms, some underlying utility function can be specified. This provides the rational for representation of consumer behaviour in a continuous utility function of an ordinal character and its augments. Theoretically, it is hypothesized that a rational individual will arrange and choose, in order of preference, from among alternatives or available bundles of products and services. Such preference decisions require the processing of information on a complex set of augments of the utility functions of individual decision makers. An understanding of the relative importance of each augment is often needed to guide implementation of appropriate interventions or strategies. Conjoint analysis provides a methodology for unravelling the ordering of preferences over well-defined augments of utility functions of individuals.

Following Louviere (1988) and Prentice & Benell (1992), aggregate utility functions are used to determine universal patterns of preferences of farmers, for all respondents and hypothesized respondent subgroups. The utility function specified by Louviere is:

$$U = f[V(S_{jk})]\text{where}$$

$S_{jk} = J \times K$ array of unobserved respondent beliefs about the level of kth determinant decision attribute for the jth package of attributes (combination of socioeconomic and technical interventions):

$V(S_{jk}) = J \times K$ array which represents respondent opinions or feelings concerning the value of the jth package's position on the kth attribute;

$U_j = J \times 1$ array representing a respondent's overall utility for the jth package of attributes.

U is expanded in additive form, assuming additive decision process:

$$U_j = I + V(S_{1j}) + V(S_{2j}) + V(S_{3j}) + V(S_{4j}) + V(S_{5j}) + V(S_{6j})$$

where $V(S_{1j})$ to $V(S_{6j})$

are utilities associated with the six socioeconomic and technical interventions whose attributes were combined in orthogonally-derived packages. Every combination of attribute levels of the six interventions represents a different package that can be ranked by target respondents in preference assessment surveys.

PREFERENCE ASSESSMENT SURVEYS

Survey areas

Preference assessment surveys were conducted in 1994 in eight representative groundnut-producing villages of southern Niger. Four villages were chosen in each of two districts in different agroecological zones: Kirtachi and Tanda districts. Study villages in the Kirtachi district (Sounga Dossado, Sounga Kaina, Koura Zeino and Kirtachi Seybou) are located in the southern Sahelian zone (500–600 mm annual rainfall). Here, only women cultivate small parcels of discarded or unwanted land to groundnut. On the other hand, study villages in the Tanda district (Bouma, Hankoura, Talambou, Tanda) are located in the northern Sudanian zone (700–800 mm annual rainfall). Here, both men and women cultivate groundnut (Table 1) on separate regularly cultivated fields and make independent production decisions. Another important distinguishing feature between the two districts is that the Tanda district, unlike the Kirtachi district, is located close to the borders of Benin and Nigeria. Therefore, farmers in the Tanda area have better access to cross-border trade. This proximity and the more rain-assured conditions in the Tanda district are important reasons why farmers in the Tanda district generally have longer experience in groundnut production (Table 1).

TABLE 1
Characteristics of Groundnut Producers Surveyed in Niger

	Number of farmers	
	Kirtachi district	*Tanda district*
1. Gender-wise distribution of sample		
Men	0	37
Women	47	17
2. Experience in groundnut production (years)		
1–10	10	8
11–20	20	19
>20	17	27

Sample farmers and survey procedure

A rapid preliminary informal appraisal of groundnut producers, scientists and extension personnel was conducted to assess constraints and preferences for external intervention by research and policymakers. The key constraining factors for which interventions are desired are: market for produce; production credit; small-scale groundnut oil processing facilities; fertilizer supply; and problems related to access to good land for groundnut production. The latter factor is particularly important in the Kirtachi district where the women can only have access to land not required for pearl millet (*Pennisetum glaucum* L. Br.) production. Some farmers also expressed a desire for access to appropriate and productive varieties.

In each village, all groundnut producers were enumerated. Based on hypotheses that gender and experience in groundnut production influence the set of socioeconomic constraints that affect production decisions, respondents were purposively chosen to ensure proportional representation by gender and years of experience in groundnut cultivation. A total of 101 respondents were chosen as the survey sample.

Conjoint analytical method is typically used to determine consumer preferences (Prentice & Benell, 1992; Baker & Crosbie, 1993). It has particular value in unravelling attribute preferences embedded in complex choice decision-making processes. The robustness of the conjoint analysis methodology has been confirmed in Monte Carlo studies (Carmone *et al.*, 1978). The methodology was used to combine attributes of the six interventions into eight packages used in surveys. Each of the socioeconomic and technical interventions was specified at two attribute levels: yes, to signify changes to provide greater access or availability; and no, to signify the *status quo*. A full factorial of six factors having two levels each, generates 64 (2^6) cases for comparison. Due to the impracticality or difficulty farmers will have in meaningfully comparing 64 cases, conjoint analysis procedure in SPSS 6.1 Categories® module (SPSS Inc., 1994) was used to generate an orthogonal array of eight packages (see Appendix).

Each combination of attribute levels was copied on to a card. Information on the cards was carefully explained to the farmers before they proceeded to indicate the order of preference. There was no evidence of respondent burden, since farmers compared information on only eight cards. Therefore, the likelihood of erroneous rankings was minimized. Ranks of 1–8 were assigned to the cards in descending order of preference indicated by each farmer. Although ranking schemes do not provide a unique way to represent indifference (Mackenzie, 1993), rankings were adopted to avoid drawbacks of non-comparability of rating levels across respondents. Since both ratings and rankings reflect relative intensities of preferences (Mackenzie, 1993), the

choice of ranking satisfactorily permits the accomplishment of the objective of the paper.

MODEL SPECIFICATION AND ESTIMATION

In the estimation of utilities, rankings assigned by farmers to the cards were regressed against attributes corresponding to the combination of socioeconomic and technical interventions. Ordinal discrete choice estimation procedure, ordered probit, was used instead of ordinary least squares. This avoided the implicit assumption of cardinal utility indices—each interval implies the same utility difference regardless of level—associated with rankings (Mackenzie, 1993).

The main effect variables modelled are:

(a) Reliable market access (Gmarket) ≡ (yes = 1, no = 0);
(b) Access to credit (Gcredit) ≡ (yes = 1, no = 0);
(c) Oil extraction plant (OilEP) ≡ (yes = 1, no = 0);
(d) New productive varieties (NPvar) ≡ (yes = 1, no = 0);
(e) Fertilizer availability (FertA) ≡ (yes = 1, no = 0);
(f) Change land access rules (LandR) ≡ (yes = 1, no = 0).

The ordered probit model was specified as: PREF = $Pr[Z]$ where

$$Z = I + \theta_1 Gmarket + \theta_2 Gcredit + \theta_3 OilEP + \theta_4 NPvar + \theta_5 FertA + \theta_6 LandR$$

PREF represents the rank; Pr the cumulative normal density function; θ_1, θ_2, θ_3, θ_4, θ_5 and θ_6 are parameter estimates; and I represents the conventional intercept and appropriate interval dummies. The ordered probit procedure in SAS (SAS Institute Inc., 1989) was used for model estimation.

One of the real powers of conjoint analysis is in identifying consumer segments (Baker & Crosbie, 1993). Based on hypothesized relative importance of regional peculiarities compared with gender, appropriate subsets of the respondents were modelled in addition to an estimation for all respondents (Table 2).

DISCUSSION

Estimated models

The estimated regressions in Table 2 represent utility models for the defined groups. For all the models, L.R. chi-squares are sufficiently large, as compared with the associated degrees of freedom, that there is no null

TABLE 2

Estimated Ordered Probit Regressions on Farmer Utilities Associated with Socioeconomic and Technical Options Influencing Groundnut Production in Niger, West Africa

Socioeconomic and technical interventions	*All respondents* Estimate	*Kirtachi district (all women)* Estimate	*Tanda district (women only)* Estimate	*Tanda district (men and women)* Estimate	*All men (Tanda only)* Estimate
Guaranteed market	1.03***	2.41***	0.71**	0.81***	0.88***
(yes)	[0.31]	[0.60]	[0.35]	[0.30]	[0.32]
Guaranteed credit	1.09***	2.08***	1.07***	1.10***	1.14***
(yes)	[0.31]	[0.57]	[0.36]	[0.31]	[0.33]
Oil extraction plant	0.50*	1.48***	0.28	0.35	0.40
(yes)	[0.30]	[0.53]	[0.34]	[0.30]	[0.32]
New productive varieties	0.19	0.84	0.09	0.13	0.16
(yes)	[0.30]	[0.52]	[0.34]	[0.30]	[0.32]
Fertilizer availability	0.53*	1.54***	0.26	0.42	0.51
(yes)	[0.30]	[0.55]	[0.34]	[0.30]	[0.32]
Changed land access rules	0.0005	2.17***	−0.59*	−0.99***	−1.21***
(yes)	[0.30]	[0.59]	[0.35]	[0.31]	[0.33]
Intercept 1	−3.12	−8.38	−2.32	−2.41	−2.51
	[0.54]	[2.22]	[0.56]	[0.48]	[0.51]
2	0.65	2.28	0.58	0.59	0.60
	[0.24]	[1.41]	[0.25]	[0.21]	[0.23]
3	1.07	3.00	1.01	1.03	1.04
	[0.27]	[1.43]	[0.29]	[0.25]	[0.27]
4	1.43	3.57	1.36	1.41	1.45
	[0.29]	[1.45]	[0.31]	[0.27]	[0.29]
5	1.80	4.09	1.74	1.83	1.89
	[0.30]	[1.47]	[0.33]	[0.30]	[0.32]
6	2.27	4.74	2.21	2.35	2.45
	[0.33]	[1.51]	[0.37]	[0.33]	[0.36]
7	2.95	5.56	2.85	3.08	3.26
	[0.39]	[1.58]	[0.43]	[0.40]	[0.45]
L. R. chi-square	2963	1049	510	1562	1042
Degree of freedom	365	288	246	344	323

Notes: [ ], contain standard errors; levels of significance of parameter estimates: ***≡1%; **≡5%; *≡10%.

model. Even though the utility model for women only in Tanda district has a relatively smaller L.R. chi-square, due primarily to the smaller sample size (Table 1), the same significant factors are similarly observed in utility models of other groups. Therefore, each model has some significant information in it. The similarity of values used to represent the two defined aspects of each factor, permits an interpretation of preference ordering on the basis of the relative sizes of significant coefficients. This implies that the factor with the largest significant coefficient looms largest in the preferences of respondents in the defined group. The conventional intercept and interval dummies represent shift factors that are not relevant to subsequent discussions.

Access to credit

In all the estimated probit models, utilities for access to credit are highly significant (Table 2). In groundnut production systems of West Africa, credit is needed due to the large financial outlays required for hiring the services of traction for ploughing even on small plots, to enhance root and pod development and labour for weeding as well as seed purchases in some cases. Since the groundnut farmers are mostly resource-poor, they lack sufficient liquidity for timely financing of production activities. Previous research in Niger found that lack of access to credit prohibits smallholder farmers from assuming risks of financial leverage associated with adoption of new technology (Krause *et al.*, 1990; Immink & Alarcon, 1993). Also, the adoption of new technology in Niger was found to be very sensitive to the amount of equity capital (Krause *et al.*, 1990). Despite the importance of liquidity offered by access to credit, there is no rural financial intermediation by formal credit institutions. The high cost of intermediation in dispersed and thin rural markets, lack of acceptable collateral and high default rates inhibit the extension of the services of formal credit institutions. To overcome these problems and facilitate successful technological change, innovative strategies are required to reduce costs of rural financial intermediation which provides small farmers with credit. These strategies could include risk-sharing schemes between farmers and their partners (Krause *et al.*, 1990), the spreading of credit over farm and non-farm activities that can help farmers build up their own liquidity (Reardon *et al.*, 1994), and the linking of formal and informal local credit/savings organizations.

Access to markets

Similarly, in all the estimated probit models, utilities for access to a reliable market for groundnut pods are highly significant (Table 2). Lack of market access reduces gross margins (Immink & Alarcon, 1993). In attempts to provide market access to producers, most West African groundnut-producing countries operated parastatals with mixed success. Parastatals not only provide inputs on credit but also facilitate an annual injection of improved seed stock where necessary (Goetz, 1993). In some countries, such as Niger, the parastatals responsible for groundnut pod purchases have folded up. Their continued existence in countries which still have them is quite tenuous in this era of internal trade liberalization and disengagement from operation of state-sponsored marketing boards. Also, an important lesson from agricultural development success stories is that government interventions should emphasize improved functioning of markets and promote the development of markets over time rather than replace markets with bureaucratic

organizations such as a grain marketing board (Johnston, 1993). Revitalization of West African markets for groundnut depends largely on opportunities for exports to Europe and North America. Most groundnut-exporting countries lost market shares because of concerns about the high levels of aflatoxin contamination. Therefore, greater access to export markets is particularly dependent on progress in reducing the levels of both pre-harvest and post-harvest aflatoxin contamination. This places particular premium on the development of aflatoxin-resistant lines and post-harvest management techniques that limit aflatoxin contamination, by international and national research institutes.

Availability of more productive varieties

In contrast to access to credit and market for pods, all respondents and subgroups have the least and practically no utility for the introduction of new more productive varieties *per se* at the present time (Table 2). The implication of this finding is that high yield should not be greatly emphasized in breeding objectives and cultivar evaluation. Under these circumstances, it will be more useful for breeding objectives and cultivar evaluation criteria to emphasize alleviation of specific constraints, such as aflatoxin which adversely affects marketability of pods and foliar diseases which alone cause up to 50% yield losses (Waliyar, 1991). This shift in emphasis will foster the development of groundnut cultivars which indirectly increase yield through reduction in losses to foliar diseases, such as leaf spot disease and improve the marketability of pods because of a higher degree of resistance to aflatoxin.

Reform of land access rules

Security of tenure is often cited as necessary for stimulating agricultural investment and resource conservation (Feder, 1985). In addition, research shows that adoption of improved seed varieties or fertilizer may be constrained by lenders' reluctance to extend credit for working capital to untitled farms (Roth *et al.*, 1993). Also, the availability of transferable land title increases the holder's access to formal credit and adoption of land improvement investments (Feder & Onchan, 1987). However, although theoretical and empirical evidence show that tenure security is necessary, it is not sufficient for the adoption of productivity-enhancing technology in agriculture (Roth *et al.*, 1993). As the results of this study show, resolution of tenure security problems may prove to be less useful to the groundnut farmers than access to reliable market and credit.

A remarkable finding of this study is the regional diversity in the usefulness of changes to existing land access rules. Negative utility estimates for a change in land access rules variable (LandR) in the Tanda district suggest

that a reform of existing land access rules is viewed as undesirable in the Tanda region, particularly by the men. Farmers of both genders in the Tanda region explained that they accord greater priority to groundnut production for cash and regularly rotate millet or sorghum fields with those allocated to groundnut. Therefore, farmers in Tanda district have no barriers to allocating any land to groundnut production. This is why they could experience significant losses of utility (negative parameter estimate) if changes to current rules on access to land allocated to groundnut production occur. In contrast, groundnut producers in the Kirtachi district (only women) explained during preliminary informal surveys that they are allowed to use only discarded or unproductive land for groundnut or vegetable production, while the best land is allocated in priority by farm households to the production of subsistence millet. The natural unproductiveness of plots cultivated to groundnut, uncertainty and frustration groundnut farmers in Kirtachi experience with respect to access to land explain the significant utilities to be gained from changes to current rules on access to land for groundnut production. The location-specificity of the usefulness of changes to traditional land access rules argues against blanket country-wide pursuit of land tenure reforms on the basis of localized studies. There is a need to properly diagnose and understand the relevance of land tenure reforms from the perspective of farmers of different regions even within the same country.

Availability of fertilizer and local oil press

Other notable findings are regional diversities in intensity of preferences for availability of fertilizer and local small-scale groundnut oil press. In the case of fertilizer, groundnut farmers in Kirtachi district, unlike their counterparts in the Tanda district, can only allocate unwanted and invariably nutrient-mined lands to groundnut production. Therefore, significant utility could be gained from the availability of fertilizers to permit productivity improvements. The diversity in utilities to be derived from availability of local groundnut oil presses may be partly due to relative proximity of the two districts to markets for groundnut pods in Benin and Nigeria. Farmers in the Tanda district have better access to cross-border trade in groundnut pods, while with the more reclusive location of the Kirtachi district, local oil production capability will reduce losses from damage to pods in storage and facilitate the marketing of their produce.

Gender versus regional diversity

Based on the diversity of utility gains between women from Tanda and Kirtachi districts, and the closer identity of utilities of the different interventions

across genders in Tanda district, we deduce that there is no need for gender-based targeting of interventions. Prioritization based on observed utilities will benefit both gender components. The results of this study suggest rather that regional peculiarities strongly influence the utilities of the interventions.

CONCLUDING REMARKS

Donors and research managers are increasingly demanding evidence of farm-level impact of investments in agricultural research by institutes affiliated to the Consultative Group on International Agricultural Research (CGIAR) and their partners in the national agricultural system (NARS). Widespread adoption by farmers of technical options produced by research is an important prerequisite to providing tangible proof of the impact of research on productivity, incomes and nutrition of target farmers. Yet, widespread adoption of technical options is contingent on the existence of a conducive socioeconomic, institutional and policy framework. At the crop level, the usefulness of accessibility to a range of technical, institutional and policy options can be deduced from utilities farmers attach to possible interventions. Conjoint analysis and ordered probit procedures were used to estimate these utilities for groundnut farmers in Niger.

Empirical evidence in this paper suggests that the alleviation of market and credit constraints provide greater utilities to farmers than the availability of more productive groundnut varieties. This confirms research findings in the Sahel (Breman, 1995), which suggest that efforts to create more favourable socioeconomic conditions are often more useful than the promotion of farmer adoption of technical options. It is reasonable to conclude from this study that lack of access to reliable markets for groundnut and credit are binding constraints in the groundnut-producing areas. Under these conditions, farmers derive very little utility from adoption of new highly-productive varieties and possibly improved fertility to produce more unsaleable pods. Future research may specifically design interaction terms to test hypotheses that lack of credit and lack of market access adversely affect utilities for new more productive varieties.

We conclude from the findings of this study that reform of land access rules or provision of small-scale local oil extraction plants may not be a panacea in all regions even within the same country. Therefore, there is a need for the disaggregation of utility analysis across regions to detect evidence of regional peculiarities. This will avoid the danger of a generalized application of perceived remedies which can be useful in some areas but detrimental to the interest of producers elsewhere.

The conjoint analysis and ordered probit methodologies used to evaluate technical and socioeconomic factors that influence crop production decisions present some advantages over simply asking farmers to rank the importance of factors individually. Typically, well-structured multi-sector interventions are more likely to make a substantial impact than single uncoordinated efforts. With increasing scarcity of resources, there is a need to group a limited combination of the most effective intervention parameters based on tradeoffs which farmers are willing to make. Yet, it is not easy to perceive possible tradeoffs from individual ranking of factors. The methodologies used in this paper, unlike simple ranking of the importance of individual factors, allow decision makers to confront farmers with sets of tradeoffs. The ranking of the sets of tradeoffs permits extraction of information on utilities associated with the component factors. This provides a more rigorous and theoretically sound basis for demand driven prioritization of alternative interventions.

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APPENDIX

Orthogonally-selected Combinations of Attribute Levels of Socioeconomic and Technical Options Evaluated by Groundnut Producers in Niger

	Attribute levels of socioeconomic or technical options					
Attribute level combination package	*Guaranteed market*	*Credit available*	*Provision of cottage oil press*	*Productive varieties available*	*Fertilizer available locally*	*Reform of land access rules*
1	Yes	Yes	Yes	Yes	Yes	Yes
2	Yes	No	No	No	Yes	Yes
3	No	Yes	Yes	No	No	Yes
4	Yes	Yes	No	No	No	No
5	No	Yes	No	Yes	Yes	No
6	Yes	No	Yes	Yes	No	No
7	No	No	Yes	No	Yes	No
8	No	No	No	Yes	No	Yes