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Utilizing conjoint analysis to design modern crop varieties: empirical example for groundnut in Niger

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Abstract

Preferences for monetary and non-monetary plant traits influence modern crop variety adoption decisions of farmers. To enhance adoption probability of modern crop varieties, it is necessary to identify and focus research on traits that significantly contribute to utility while de-emphasizing insignificant plant attributes. This paper illustrates the potential for applying conjoint analysis to aid the design and targeting of client-responsive modern crop varieties. Farmers ranked eight orthogonally-derived plant trait combinations used in an illustrative example. Utilities were estimated using the choice-probability-based method of ordered probit. Results showed that conjoint analysis can differentiate significant and non-significant traits of modern crop varieties. The usefulness of applying conjoint analysis over identifiable disaggregated groups of a sample was also evident. Future application of conjoint analysis to the design and targeting of modern crop varieties should carefully consider sample composition and size to permit the estimation of relevant sub-models for desired farmer segments. © 1997 Elsevier Science B.V.

1. Introduction

Transfer of scientific knowledge which improves technology generation capacity is useful for the creation of location-adapted technology (Hayami and Ruttan, 1985, p. 166). This transfer includes methodologies that can be used in the design and generation phases of modern crop varieties (MCV). The specific objective of this paper is to illustrate the potential for using conjoint analysis (CA), a methodology most frequently used in market research, to aid the design and targeting of modern crop varieties.

Adoption decisions of farmers are influenced by subjective assessments of technology characteristics or attributes (Kivlin and Fliegel, 1966, 1967; Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Adesina and Seidi, 1995). Early involvement of farmers at the stage of varietal selection on experiment stations has proved useful in the identification of desirable characteristics or attributes of modern crop varieties (Sperling et al., 1993; Baidu-Forson, 1997). Application of conjoint analysis provides an additional and theoretically-sound basis for incorporating trait or attribute preferences of farmers in technology design and targeting.

Conjoint analysis, a powerful extension of close-ended contingent valuation method, covers both the theory and methods used to design, implement and analyze judgement data (Green and Srinivasan,

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1978). It involves evaluative rankings or ratings of a set of multiattribute alternatives by individuals. Essentially, conjoint analysis permits decomposition of individual evaluations of a set of multiattribute alternatives into part-worth utilities or values. In this way, conjoint analysis allows for the measurement of consumer preferences between items with multiple attributes. The underlying premise is that consumers evaluate a product by combining utilities from each attribute (Baker and Crosbie, 1993). The robustness of the conjoint analysis has been confirmed in Monte Carlo studies (Carmone et al., 1978).

Plant traits which influence modern crop varieties adoption decisions of farmers include yield, perceptions of ease of cooking and threshing (Adesina and Zinnah, 1993; Adesina and Baidu-Forson, 1995; Adesina and Seidi, 1995). Net return or profit maximizing framework takes into account only the monetary factor such as yield, while both monetary and non-monetary factors can be taken into account within a utility-maximizing framework. Because of the importance of non-monetary plant traits in adoption decisions and preferences of farmers, utility is a more complete index of satisfaction than expected net return. In addition, a comparison of conjoint utility model and expected profit model in the prediction of actual behavior has indicated that small farmers are utility maximizers rather than profit maximizers (Mohayidin, 1982).

The theoretical basis for the application of conjoint analysis is presented in Section 2. This is followed by a presentation of the study areas, materials and survey techniques (Section 3). Section 4 covers model estimation while results and discussion of the illustrative example for groundnut producers are presented in Section 5. Finally, Section 6 presents conclusions and implications of drawbacks of the illustrative example for future research.

2. Methods

In consumer theory, demand functions are derived from considering a model of preference-maximizing behavior coupled with underlying economic constraints (Varian, 1978). Preference-maximizing behavior is applicable to evaluation and choice of modern crop varieties. Let G represent a modern crop variety which can be described as a bundle of N constituent traits such that $G=(g_1 \ldots g_N)$ where g_i $(i=1 \ldots N)$ refers to the ith trait or attribute. Let utility be additively separable in G and other goods Z, so that $U^* = U[G(g_1 \ldots g_N)] + U'[Z]$ and the marginal rate of substitution between any pair of traits is independent of the consumption of the level of other goods Z. If the modern crop variety has a price or cost P_G, utility function may be expressed in indirect form $V[g_1 \ldots g_N, P_G, Y]$ where Y represents individual's income. The indirect utility function may be specified linearly as: $V=a+b_1 g_1 + \ldots b_N g_N + b_p P_G + b_I Y$ where the b's are marginal utilities.

If the marginal utility of money is assumed constant, $b_p = b_I$, the income term drops out upon estimation since the individual's income does not vary across alternative bundles of G (Hanemann, 1984). If bundles $G^0(\ldots g_i^0, \ldots, P_g^0)$ and $G^1(\ldots g_i^1, \ldots, P_g^1)$ are compared, where g_i and P_g are varied such that an individual is indifferent between G^0 and G^1 then the compensated measure represented by marginal willingness to pay (WTP) for trait g_i is $-V_{G_i}/V_{P_g}$ (Mackenzie, 1992). While P_G and a single unpriced trait are varied in referenda contingent valuation method, which is more resistant to response bias than open-ended contingent valuation method, conjoint analysis allows multiple attributes to vary simultaneously (Mackenzie, 1992). The motivation for using CA for the design of MCV is to allow multiple attributes to vary simultaneously.

Contingent ratings or rankings are typically used in conjoint analysis. While ratings provide the same preference ordering as rankings, they are more efficient and have the added advantage of representing indifference or ambivalence uniquely unlike rankings. However, ratings have an important theoretical limitation of non-comparability of rating levels across respondents. This is particularly important where no particular rating level designates ambivalence or indifference. Due to greater comparability across respondents, rankings were used at the risk of biases if significant ambivalence or indifference exist between attribute combinations used in the illustrative example presented in this paper. Also, although ranking schemes do not provide a unique way to represent indifference, both ratings and rankings reflect relative intensities of preferences (Mackenzie, 1993).

When respondents compare C attribute/trait profile description cards, which describe permutations of attributes of G, and assign rankings (indices of latent utilities) then the contingent rank ordering of the cards implies:

$$V[G_1,Y-\mathrm{WTP}_1] \geq V[G_2,Y-\mathrm{WTP}_2]$$
$$\geq V[G_3,Y-\mathrm{WTP}_3] \geq \ldots \geq V[G_C,Y-\mathrm{WTP}_C]$$

where Y is income.

The rankings explicitly assign indices of latent utilities to the cards and hence permit direct estimation of utility as an empirical function of the vector $\boldsymbol{G}$ (Mackenzie, 1993). Individual i's utility from attribute combination profile description card j can be decomposed into systematic and random portions: $V_{ij}[G_j,C_i] = \nu[\boldsymbol{G}_j,C_i] + e_{ij}$ where ν represents a systematic utility index common to all respondents (Mackenzie, 1993). If C cards are compared, there are $C(C-1)/2$ non-redundant pairwise comparisons. Ranking approach reveals preference ordering efficiently but the probability of inconsistent rankings can increase as C gets large. Elicitation of simultaneous rankings of card, instead of pairwise comparisons of attributes, which improves informational efficiency (Mackenzie, 1992) was used in this paper.

3. Area description, materials studied and survey techniques

We illustrate the potential usefulness of conjoint analysis for deriving client preference-based design of modern crop varieties with an example for groundnut (*Arachis hypogaea* L.). Preference assessment surveys were conducted in 1994 in eight villages situated in two groundnut-producing regions of Niger. One of the study areas, in Kirtachi district, is located in the southern Sahelian zone. It has a shorter crop season environment and, with an annual rainfall of 500–600 mm, is at the driest margin of groundnut producing areas of West Africa. Although it has a weekly rural market, it is about 75 km from the nearest urban market. Further south in the north Sudanian zone is the second study area, in Tanda district. It has an annual rainfall of 700–800 mm and a longer rainy season. The cross-border markets in Nigeria and Benin as well as an urban market about 20 km away are readily accessible and frequented by farmers in the Tanda area. Because of the importance of taking into account location specificity of agricultural technical change (Ruttan and Hayami, 1973; Ruttan, 1975) and the relevance of contrasting proximity of the two study areas to markets to preference for modern variety of groundnut, separate models were estimated for each study area.

Table 1
Characteristics of groundnut producers surveyed in Niger

	Number of farmers	
	Kirtachi district $n=47$	Tanda district $n=54$
1. Distribution of respondents by gender		
Men	0	37
Women	47	17
2. Age distribution (years)		
≤ 39 years	24	18
≥ 40 years	23	36
3. Tillage equipment ownership (proxy for economic status)		
No	45	27
Yes	2	27

A total of 101 respondents were purposely chosen from the two study areas on the basis of hypotheses that location and gender affect preference decisions. The sample size drawn from each location and gender group was in proportion to its representation in the population of enumerated groundnut producers. Table 1 presents a summary composition of the survey sample for gender, age group and tillage equipment ownership. In the Tanda area, men and women cultivate separate groundnut fields and make independent varietal choice decisions. However, only women cultivate and choose groundnut varieties consistent with their preferences in the Kirtachi area. Tillage equipment (plough) is used to loosen up soil and enhance pod development. If ownership of tillage equipment is used as a rough proxy for economic status then proportionally more female groundnut farmers, in the Kirtachi area, belong to lower economic status. Tillage ownership is more even in the Tanda area.

Cultivated groundnut varieties differ in crop cycle. Therefore, choice of modern crop variety influences yield stability and potential risk of crop loss, particularly in semi-arid regions of West Africa characterized by unpredictable length of cropping season. Foliar diseases—particularly early leaf spot (*Cercospora arachidicola* Hori), late leaf spot (*Cercosporidium personatum* (Berk and Curt.)) and rust (*Puccinia arachidis* Speg.)—are major constraints to groundnut production in West Africa (Waliyar et al., 1993, 1994). Also, pod yield, haulm yield and grain color were identified by groundnut producers and scientists, during a broad informal survey, as important factors influencing groundnut choice decisions. Therefore, for the purposes of this empirical example to illustrate the potential of conjoint analysis for designing and targeting modern crop varieties, five varietal attributes retained for study are: plant type (spread plant type with long crop cycle versus erect plant type with short crop cycle); pod yield ('improved' or 'current'); haulm yield ('improved' or 'current'); leaf spot disease resistance ('yes' or 'no'); and grain color ('red' or 'rose/tan').

For simplicity, only five traits were examined. In practice, there are several more traits that could vary simultaneously. If an orthogonal set, produced from incorporating several relevant traits, is too large for an individual respondent to reasonably compare correctly, a common practice is to include an extra pseudo-attribute in the design. The pseudo-attribute, since it is orthogonal to the other attributes specified, can be used to identify equivalent subsets or 'blocks' of cards (Bretton-Clark Inc., 1987) which can be incorporated in different versions of survey so that each respondent compares cards within only one block (Mackenzie, 1992).

A full factorial of five attributes having two levels each, generates 32 cases for comparison. It is difficult for farmers to judge 32 cases in a meaningful way even if it is practical to conduct that many comparisons. Due to transitivity of preferences, (i.e., $U[G^1] > U[G^0]$ and $U[G^2] > U[G^1]$ imply that $U[G^2] > U[G^0]$), an orthogonal set of trait combinations can sufficiently be used to reflect preference profiles. With the aid of SPSS 6.1 Categories® module (SPSS Inc., 1994), an orthogonal array alternative to the full factorial was designed (Table 2). Each array was copied onto a card describing varietal attribute characteristics. Respondents were shown photos of short duration/erect and long duration/spread groundnut plant types. The inherent characteristics of each plant type (Table 2) were explained. Definitions of 'improved' and 'current' were provided to respondents. In the case of pod and haulm yields, 'improved' was defined as twice the average yield (500–1000 kg ha^{-1} for pods, 900–1500 kg ha^{-1} for haulms) of the farmer's best local variety (similar to cv. 55–437). This level of improvement has been achieved in on-farm trials of new varieties in Niger. 'Current' designates the average yield of the best local variety. Farmers compared information on the eight attribute profile description cards and arranged the cards in order of preference.

Table 2
Orthogonal main-effects plans evaluated by groundnut producers in Niger

Orthogonal plan	Groundnut plant and grain traits				
	Plant type [a]	Pod yield [b]	Haulm yield [b]	Foliar leaf spot resistance	Grain colour
1	Spread/long cycle	Current	Current	No	Rose/tan
2	Erect/short cycle	Current	Current	Yes	Red
3	Spread/long cycle	Improved	Current	Yes	Rose/tan
4	Erect/short cycle	Current	Improved	No	Rose/tan
5	Spread/long cycle	Improved	Improved	No	Red
6	Erect/short cycle	Improved	Current	No	Red
7	Erect/short cycle	Improved	Improved	Yes	Rose/tan
8	Spread/long cycle	Current	Improved	Yes	Red

[a] Spread/long cycle plant types have: maturity of 110 to 120 days; 2–3 grains per pod; small grains; low oil yield; and seed dormancy. Erect/short cycle plant types have: 90 days maturity; 2 grains per pod; medium-sized grains; medium oil yield; and no seed dormancy.
[b] 'Improved' has twice the average yield of best local variety while 'currents' has same yield as the best local variety (similar to cv. 55–437).

Ranks of one to eight were assigned to the attribute profile description cards in descending order of preference indicated by each farmer. The rankings and the attribute combinations on corresponding cards were the data used in model estimation. Because there were only eight cards to compare, the survey did not experience respondent burden and hence the likelihood of erroneous rankings was minimized. Transitivity of preference orderings were randomly checked for each respondent with the aim of detecting occurrence of erroneous rankings.

4. Model estimation

Empirical utility functions were estimated by regressing rankings against attributes on preference profile cards. To avoid the assumption of cardinal utility indices associated with the use of ordinary least squares (OLS) for estimation, an ordinal discrete choice procedure (ordered probit) was preferred. Since rankings and ratings all yield bounded discrete utility indices, the empirical utility function can be estimated via probit or logit (Mackenzie, 1993, p. 597). For multi-level response with outcomes I_i for $i = 1,2,\ldots,c$, the probability, p_j, of observing I_i is:

$$p_1 = R + (1 - R)Z(\boldsymbol{x}'\boldsymbol{b})$$

$$p_2 = (1 - R)(Z(a_2 + \boldsymbol{x}'\boldsymbol{b}) - Z(\boldsymbol{x}'\boldsymbol{b})$$

$$p_j = (1 - R)(Z(a_j + \boldsymbol{x}'\boldsymbol{b}) - Z(a_{j-1} + \boldsymbol{x}'\boldsymbol{b})$$

$$p_c = (1 - R)(1 - Z(a_{c-1} + \boldsymbol{x}'\boldsymbol{b}))$$

where $\boldsymbol{b} \equiv$ vector of parameter estimates; $Z \equiv$ normal cumulative distribution function; $\boldsymbol{x} \equiv$ vector of independent variables; $p \equiv$ probability of response; $R \equiv$ response rate. The c-level response produces $c - 2$ additional parameters, $\boldsymbol{a}$'s, denoted 'Inter' (SAS Institute Inc., 1989). The main effect variables $(\boldsymbol{x})$ modelled are:

PlantT $\equiv$ plant type (erect/short cycle $\equiv$ 1, spread/long crop cycle $\equiv$ 0); PodY $\equiv$ pod yield (improved $\equiv$ 1, current $\equiv$ 0); HaulmY $\equiv$ haulm yield (improved $\equiv$ 1, current $\equiv$ 0); LeafSR $\equiv$ leaf spot resistance (yes $\equiv$ 1, no $\equiv$ 0); Gcolor $\equiv$ grain color (rose/tan $\equiv$ 1, red $\equiv$ 0).

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

$$Z = I + \delta_1 \text{PlantT} + \delta_2 \text{PodY} + \delta_3 \text{HaulmY} + \delta_4 \text{LeafSR} + \delta_5 \text{GColor}$$

δ_1, δ_2, δ_3, δ_4, δ_5 are parameter estimates (embedded in the vector $\boldsymbol{b}$); and I represents the conventional intercept and appropriate interval dummies.

Generally, the combination rule for estimating utility function is based on a choice between the additive and quadratic models (Baker and Crosbie, 1993). The additive model specified in this illustrative example imposes a restrictive assumption of no significant interactions between attributes. However, conjoint studies typically estimate only the main effects and assume away interaction effect (Green and Srinivasan, 1990). In cases where interaction effects are very important and need to be specified, 'compromise' designs can be used to measure selected two-way interactions (Carmone and Green, 1981). Baker and Crosbie (1993) outline reasons why specification of interaction terms often does not increase predictive power of conjoint analysis models. Where interaction terms need to be specified, it is necessary to make a judgement as to whether model validity would be better because of increased realism or worse because of the estimation of several additional parameters (Hagerty, 1986). The importance of the bias depends on whether or not gains from realism in specifying interaction terms are significantly greater than losses in efficiency because of the inclusion of additional variables. In this paper, no interaction terms are specified. We acknowledge misspecification error that could occur if the assumption of lack of significant interactions between the traits examined does not hold.

To examine the value of disaggregated conjoint analysis across location and gender, five models were estimated for: All respondents; respondents in Kirtachi area; respondents from Tanda area; women across in both Kirtachi and Tanda areas; and men only in Tanda.

5. Results and discussion

In all five models, parameter estimates for leaf spot resistance, improved pod yields and short crop cycle associated with erect plant type have the expected positive sign and were significant (Table 3). On the other hand, parameter estimates for grain color were not significant in all the five models. A major implication of these findings is that since farmers in the study areas would derive significant satisfaction from groundnut varieties that incorporate leaf spot disease resistance, improved pod yield and short crop cycle, these factors should loom large in the design and targeting of modern groundnut varieties. On the other hand, farmers in the study areas will not derive satisfaction from research focussed on grain color, at least for now.

The significance of utilities from leaf spot disease resistance is likely to be due to yield losses of up to 50% which occur as a result of the combined effects of foliar diseases in West Africa (Waliyar, 1991). The high cost of chemical control has necessitated the development of disease resistant cultivars (Waliyar et al., 1993). The availability of modern groundnut varieties that incorporate leaf spot disease resistance provides a less costly means to overcome the disease constraint to production. This supports emphasis on development of leaf spot disease resistant lines, and the search for stable sources of resistance to incorporate into modern groundnut varieties, by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and research partners in the national agricultural systems (NARS). Short crop cycle, associated with erect groundnut plants, provides greater assurance of yield stability. This is particularly important in the semi-arid zones of West Africa, which are increasingly experiencing unpredictable and shorter crop seasons.

Table 3
Estimated ordered probit regressions for groundnut varietal trait preferences of farmers in Niger, West Africa

Attribute/level	All respondents $n = 101$		Kirtachi district (all women) $n = 47$		Women(Kirtachi and Tanda) $n = 64$		Tanda district (Men and women) $n = 54$		All men (Tanda only) $n = 37$	
	Estimate	Chi-Sq.	Estimate	Chi-Sq.	Estimate	Chi-Sq.	Estimate	Chi-Sq.	Estimate	Chi-Sq.
Erect/short cycle plant	2.16 **		1.33 **		1.77 **		3.90 **		3.53 **	
type (PlantT)	[0.20]	113.54	[0.31]	18.14	[0.34]	26.28	[1.09]	12.69	[0.80]	19.23
Pod yield	2.43 **		3.11 **		2.54 **		3.08 **		2.96 **	
(PodY)	[0.21]	129.27	[0.44]	51.11	[0.39]	41.76	[1.05]	8.60	[0.78]	14.35
Haulm yield	0.73 *		0.32		0.49		1.73		1.64 *	
(HaulmY)	[0.19]	14.94	[0.31]	1.06	[0.33]	2.21	[1.03]	2.83	[0.75]	4.71
Leaf Spot resistance	2.68 **		339 **		2.82 **		3.41 **		3.20 **	
(LeafSR)	[0.22]	146.64	[0.45]	55.90	[0.41]	47.16	[1.08]	10.02	[0.79]	16.18
Grain colour	0.01		0.31		0.10		−0.14		−0.13	
(Gcolour)	[0.17]	0.007	[0.38]	0.67	[0.33]	0.08	[0.50]	0.08	[0.41]	0.10
Intercept	−6.75		−7.65		−6.69		−9.64		−9.00	
	[0.52]	168.01	[1.07]	51.16	[0.94]	51.14	[3.05]	10.01	[2.22]	16.39
Inter. 2	1.45		1.72		1.44		2.24		2.07	
	[0.27]		[0.55]		[0.49]		[1.48]		[1.09]	
Inter. 3	2.18		2.83		2.25		3.02		2.79	
	[0.28]		[0.64]		[0.53]		[1.49]		[1.10]	
Inter. 4	2.75		3.56		2.87		3.64		3.37	
	[0.29]		[0.66]		[0.54]		[1.50]		[1.11]	
Inter. 5	3.34		4.27		3.49		4.24		3.95	
	[0.30]		[0.69]		[0.57]		[1.52]		[1.12]	
Inter. 6	4.09		5.20		4.29		5.00		4.67	
	[0.33]		[0.73]		[0.62]		[1.56]		[1.15]	
Inter. 7	5.48		6.54		5.58		7.40		6.90	
	[0.42]		[0.85]		[0.75]		[2.66]		[1.92]	
LR. Chi-square.	2117.99		911.07		1334.15		991.85		705.52	
Degrees of freedom	884		226		240		233		233	

Notes: [ ] contain standard error. Levels of significance ** $P < 1\%$; * $P < 5\%$; Chi-Square values for variables and intercept are for 1 df.

Comparison of parameter estimates for all respondents with those of sub-models points to the merit of conjoint analysis across disaggregated locations and gender. The model estimated for all respondents suggests that farmers would derive satisfaction from the inclusion of haulm yield in the design of modern groundnut varieties. Yet, district-level disaggregated models for Kirtachi and Tanda show no need to include haulm yield in the design of modern groundnut varieties. It is apparent, however, from the sub-model for men only in the Tanda area that haulm yield significantly improves utility. Significant gender-based utility differences associated with plant traits have been observed for millet *Pennisetum glaucum* L. Br. (Baidu-Forson, 1997). The collection, binding and sale or feeding of haulm to livestock are predominantly tasks of men. There could be the interactive effect of gender and proximity of Tanda study area to strong cross-border markets. Therefore, it is not possible to definitively conclude that gender-based differences alone account for utility of haulm yield to men in the Tanda area. This is particularly because of the absence of men groundnut producers in the Kirtachi area and inability to estimate a sub-model for women only in the Tanda area, because of lack of variation in rankings by the small sample size of 17. Nevertheless, the results of the illustrative example points to opportunities for identifying traits most preferred by well-defined components of farmer domains: location; gender; or location by gender interactions. This demonstrates the potential for using conjoint analysis to aid the design and targeting of modern crop varieties.

6. Conclusions

Client-oriented improvement of modern crop varieties is an important focus of donors, research institutes and networks operating in West Africa. The achievement of this objective requires knowledge of the preferences of farmers. The application of conjoint analysis provides opportunities to use preference-based method to aid the design and targeting of modern crop varieties. We learn from the illustrative example in this paper that conjoint analysis permits the identification of significant and non-significant traits or attributes of modern crop varieties. In addition, it is instructive to undertake analysis of sub-samples disaggregated by easily identifiable groups to whom specific preferred designs of modern crop varieties can be targeted. Some factors to consider when identifying farmer segments include economic status, market dependence, gender and age which influence farmer choice decisions (Moock and Rhoades, 1992, p. 8). This will allow the exploitation of the real power of using conjoint analysis in identifying preferences of consumer segments (Baker and Crosbie, 1993). Baidu-Forson et al. (1997) present an example of the value of conjoint analysis for samples disaggregated for gender groups and location.

Though the illustrative example in this paper points to the usefulness of location and gender disaggregation, the sample composition and size did not permit the estimation of separate models for all segments of gender, age and equipment ownership as proxy for economic status. It is suggested that future studies on the application of conjoint analysis to the design of modern crop varieties carefully consider sample size and composition that will permit more complete analyses for different recommendation domains. Also, the parameter estimates in this example correspond to contributions of specific attribute levels, assigned values of 1, to utility. Where there are several levels and there is interest in finding out the contribution of each level of an attribute to utility, part-worth model is more appropriate. Baker and Crosbie (1993) present an example of that approach.The strong points and particular need for the application of conjoint analysis to the design and targeting of modern crop varieties include: a theoretically-sound quantitative basis for evaluating and prioritizing demand for plant traits; and the combination of alternative feasible trait attributes without having to breed first and evaluate widely for appropriate targeting. However, the potential drawbacks of the procedure include: complications in the ordering process in cases where there are unequal number of attribute levels; the need to limit trait attributes evaluated to only those farmers are familiar with; and potential biases from immediate past experiences of farmers. Future research could compare conjoint analysis to other plant trait attribute preference assessment methods to empirically establish its relative usefulness in guiding the design and targeting of modern crop varieties.

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