INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS
ICAE
29th | Milan Italy 2015
UNIVERSITÀ DEGLI STUDI DI MILANO AUGUST 8 - 14
AGRICULTURE IN AN INTERCONNECTED WORLD

Wheat Farmers' Preferences for Wheat Traits in Punjab, Pakistan: A Choice Experiment Approach

Hina Nazli[a], Ekin Birol[b], Dorene Asare-Marfo[b], and Asjad Tariq[a]

[a] Pakistan Strategy Support Program, International Food Policy Research Institute, Islamabad, Pakistan
[b] HarvestPlus, International Food Policy Research Institute, Washington DC, USA

Abstract.

In this paper we implement a stated preference experiment to assess wheat farmers' preferences for and trade-offs between several wheat attributes, including yield, maturity period, resistance to rust, presence of zinc content, and colour of the roti (flat bread). Since zinc-biofortified wheat varieties were not available at the time this study was implemented, we employed the hypothetical choice experiment method. Choice data are collected from 1116 wheat farmers and analysed using conditional logit models, and accounting for the differences in the preferences of farmers with different size operations (marginal, small-scale and medium and large) located in the three key agro-climatic zones of Punjab. The results of this study are expected aid in the development of zinc-biofortified wheat varieties that are preferred by farmers of different sizes in different agro-climatic zones, as well as in the design of targeted delivery and marketing mechanisms for their maximum adoption.

Keywords: biofortification, zinc-biofortified wheat, choice experiment

JEL Codes: C35, C93, D12, D83, O33, Q18,

IAAE

1. Introduction

Zinc deficiency is prevalent and is particularly severe among women and children in Pakistan. Nearly 41.6 percent of non-pregnant women, 48.3 percent of pregnant women, and 36.5 percent of children are zinc-deficient (National Nutrition Survey, 2011). In addition, the incidence of stunting, an indicator of chronic malnutrition and a proxy indicator of the risk of zinc deficiency, is considerably high in Pakistan. Almost 43.7 percent of children under five years are stunted (National Nutrition Survey, 2011). Zinc is crucial for resistance to disease, control of diabetes, healing of wounds, digestion, reproduction, and physical growth. However, because of higher levels of poverty in Pakistan, many households do not have access to zinc-enriched food or zinc supplements.

One potential solution to alleviating micronutrient malnutrition is biofortification—the process of breeding and delivering staple food crops with higher micronutrient content (Saltzman et al. 2013). Biofortification could prove to be a cost-effective and sustainable strategy especially in rural areas of developing countries where the majority of the poor households' diets are comprised of staple foods and where access to food supplements and commercially marketed fortified foods is limited (see e.g., Meenakshi et al., 2010).

Wheat is the most important staple crop in Pakistan, grown over an area of 8.5 million hectares, and comprising more than 70 percent of total food grain production (GOP, 2011). The average Pakistani household consumes nearly 300 grams of wheat daily andwheat accounts for 37 percent in total daily calorie supply (FAO, 2011). Wheat consumption is much higher among poorer people (Malik et al., 2014). Moreover, according to the Biofortification Priority Index (BPI), which prioritizes countries for vitamin A, iron, and zinc biofortification interventions based on their production and consumption of target crops and the rate of micronutrient deficiency among target population, Pakistan ranks as number 5 country for the introduction of high zinc wheat among 127 countries in Africa, Asia, and Latin America and the Caribbean. Therefore, zinc-enriched wheat could be an option for addressing zinc deficiency in Pakistan.

Several zinc-biofortified wheat varieties are currently being developed and will be released in Pakistan in the coming years. The acceptability and adoption of these varieties is a big question mark for the policy makers. The historical trend shows that on average, only 20 percent of the wheat seed requirements are met through formal sector in Pakistan (Hussain, 2011). A large proportion of wheat farmers use saved seed and/or farmer-to-farmer seed transfer/exchange are common. Rest of the requirements are fulfilled by other informal sources, such as, input dealers, shopkeepers, large landlords, etc. (Nazli et al., 2014). In this situation, to design effective programs for the marketing and delivery of zinc-biofortified varieties, especially to small farmers, the Government of Pakistan, as well as the private sector need to understand the process of acceptance, adoption, and diffusion of zinc-biofortified wheat varieties.

The main objective of this study is to provide much needed information to the policy-makers about the processes of introducing zinc-biofortified wheat varieties. Such information would be helpful in designing a more cost-effective and high impact delivery and marketing mechanism for zinc-biofortified wheat varieties. We use the stated preference choice experiment method to understand wheat farmers' preferences of choosing a wheat variety, in particular, the tradeoffs they make among different production and consumption attributes of wheat varieties, and their willingness to pay for a zinc-biofortified wheat variety.   This hypothetical method was preferred, because at the time of data collection in 2011, there were no available zinc-biofortified wheat variety prototypes with which to conduct revealed experimental auctions, as done for other crops such as vitamin A biofortified orange maize (Meenakshi et al., 2012; Banerji et al., 2013), orange sweet potato (Chowdhury et al., 2011) and yellow cassava (Oparinde et al., forthcoming); and iron biofortified pearl millet (Banerji et al., 2015) and beans (Oparinde et al., 2015; Birol et al., 2015).

For the choice experiment presented here six important wheat attributes were identified. These include: yield, maturity period, resistant to rust, presence of zinc content, and colour of the roti (flat bread), and the price of wheat seed. The choice experiment data were collected through interviews with 1116 wheat farmers during October-November 2011 in twenty three districts of irrigated Punjab, representing 3 zones (rice-wheat, cotton-wheat, and mixed zones). We analyze the data using various conditional logit models that take the differences in farm types (marginal, small, and medium and large) and agro-climatic zones into conisderation. The results reveal significant differences in wheat varietal preferences across farm types and agro-climatic zones, suggesting one size fits all varieties and delivery/marketing strategies would not result in optimal level of adoption, and farm types and agro-climatic zones should be taken into consideration when developing and delivering high zinc wheat varieties.

The rest of the paper is organized as follows, the next section describes the choice experiment methodology and the data sources. Section 3 explains the choice experiment design. Section 4 presents the results of the analyses and the final section completes the paper with conclusions and policy and programmatic implications.

2. Methodology

2.1.Choice experiment theory

Among the hypothetical stated preference methods, the choice experiment method is considered to be the most appropriate one for valuing the importance of multiple traits farmers evaluate when deciding whether or not to adopt a wheat variety. This is because the choice experiment method allows for estimation not only of the value of the wheat variety as a whole, but also of the implicit values of its attributes (Hanley et al., 1998; Bateman et al., 2003). This approach has a theoretical grounding in Lancaster's attribute theory of consumer choice (Lancaster, 1966), and an econometric basis in models of random utility (Luce, 1959; McFadden, 1974).

Lancaster proposed that consumers derive utility not from goods themselves but from the attributes they provide. For illustration of the basic model behind choice experiment, consider a farmer's choice of a new wheat variety, and assume that utility depends on choices made from a set C, which includes all the possible options of different wheat varieties. This list of all options that are available to the farmer is referred to as the choice set. The farmer is assumed to have a utility function of the form

$$U_{ij} = U(Z_{ij}) \qquad (1)$$

where for any farmer *i*, a given level of utility will be associated with any alternative wheat variety *j*. Utility derived from any of the wheat variety alternatives depends on the attributes of the variety.

The random utility model is the theoretical basis for integrating choice behaviour with economic valuation in the choice experiment method. In this model, the utility of a choice is comprised of a systematic (explainable or deterministic) component, V_{ij}, and an error (unexplainable or random) component, e_{ij}, which is independent of the deterministic part and follows a predetermined distribution.

$$U_{ij} = V_{ij} + e_{ij} \tag{2}$$

The systematic component can be explained as a function of characteristics of the wheat variety as explained above, in (1). That is:

$$U_{ij} = V(Z_{ij}) + e_i \tag{3}$$

Given that there is an error part in the utility function, predictions cannot be made with certainty and analysis becomes one of probabilistic choice. Consequently, choices made between alternative wheat varieties will be a function of the probability that the utility associated with a particular wheat variety (j) is higher than that for other alternative varieties. That is to say, the probability that farmer i will choose wheat variety j over all other options h is given by

$$P_{ij} = \Pr ob\{V_{ij} + e_{ij} > V_{ih} + e_{ih}; \forall j \neq h, \forall h \in C\} \tag{4}$$

The parameters for the relationship can be introduced by assuming that the relationship between utility and attributes and characteristics follows a linear path in the parameters and variables function, and by assuming that the error terms are identically and independently distributed with a Weibull distribution (Greene, 2008). These assumptions ensure that the probability of any particular alternative *j* being chosen can be expressed in terms of a logistic distribution. This specification is known as the conditional logit model (CLM, McFadden, 1974; Greene, 2008; Maddala, 2001), and it takes the general form

$$P_{ij} = \frac{e^{V_{ij}}}{\sum_{h \in C} e^{V_{ih}}} \tag{5}$$

The conditional indirect utility function generally estimated is

$$V_{ij} = \beta + \beta_1 Z_1 + \beta_2 Z_2 + \ldots + \beta_n Z_n \tag{6}$$

where β is the alternative specific constant (ASC), that captures the effects in utility from any attributes not included in choice specific attributes. The number of wheat variety attributes considered is n. The vectors of coefficients β_1 to β_n are attached to the vector of attributes (Z).

Basic CLM assumes homogeneous preferences across sampled farmers. However, preferences may be heterogeneous and accounting for this heterogeneity enables estimation of unbiased estimates of individual preferences and enhances the accuracy and reliability of estimates of demand, participation, marginal and total welfare (Greene, 2008). Furthermore, accounting for heterogeneity enables prescription of policies that take equity concerns into account. It is important to understand who will be affected by a policy or programme (e.g., a delivery or marketing strategy) (Boxall and Adamowicz, 2002). Determination of individual heterogeneity is of particular relevance when knowledge of population segments is crucial for assessment of existence and nature of niche consumers or producers (Kontoleon, 2003).

One way of accounting for preference heterogeneity is by separating the sample into various groups (segments) and by estimating the demand function for each group separately. For example estimation of the CLM for farmers with different farm sizes (e.g., marginal, small, medium and large farmers) and/or for different agro-climatic zones (e.g., cotton-wheat, rice wheat and mixed zones) would give more accurate results of preferences within Punjab. Since it is likely that farmers with different farm sizes and/or in different agro-climatic zones are to value wheat variety attributes differently, whether or not the set of parameter estimates of the pooled model is shared across the distinct subsamples must be tested. This is done by estimating separate CLMs for each subsample, and carrying out the following test to investigate whether or not preferences differ across farm sizes and/or zones. In the case of different zones, we would test:

$$H_0 : \beta_{pool} = \beta_{zone1} = \beta_{zone2} = \beta_{zone3} \quad (7)$$

where β_x are the CLM parameter vectors of the indirect utility function in equation (6) above. Rejection of the null-hypothesis would imply that farmers in different zones and/or with different farms sizes have different demand models for wheat varieties and their attributes. This test can be conducted with a Swait-Louviere log likelihood ratio test. The test statistic is asymptotically distributed as χ^2 and is expressed as

$$\chi^2 = -2(LL_1 - LL_2) \tag{8}$$

where LL_x refers to the log likelihood statistics of the different CLMs.

2.2. Data

The data used in this paper are drawn from a survey of wheat farmers conducted by HarvestPlus and Innovative Development Strategies (IDS) during the months of October and November 2011 in Punjab, the largest province of Pakistan. Over three-quarters (76 percent) of Pakistan's wheat area is located in Punjab Province (GOP, 2011). The sample of wheat farmers was selected from 93 villages, located in 23 districts of three agro-climatic zones (the cotton-wheat, the rice-wheat, and the mixed zones).

A stratified two-stage (unequal size) cluster design was used to select the sample farmers. The three wheat production zones represented the strata or first-stage sampling unit. The second-stage sampling unit was the *mouza*, known as a "revenue village". The revenue villages were allocated proportionately across the agro-climatic zones based on the share of the zone in the total area sown with wheat. A systematic probability-proportionate-to-estimated-size approach was used for the selection of revenue villages within each agro-climatic zone using secondary data on the population size (total number of households) of each revenue village.

Following the selection of the revenue villages in the first stage and the listing of wheat-growing households, sample households were selected at random within each village. From previous surveys and research conducted in Pakistan, the non-response rate was estimated at 33 percent for interviewing conducted at the second-stage selection. This rate was applied in our study and prescribed that six spare households be selected within each revenue village. A total of 18 households were selected in each village of which 12 were interviewed. A total of 1,116 wheat farmers were interviewed in the sample survey. In the overall sample, about 32 percent of the farmers were located in the rice-wheat zone, as compared with about 41 and 27 percent in the cotton-wheat and mixed zones, respectively.

3. Choice Experiment Design

To design the choice experiment, we identified the most important six wheat variety attributes farmers consider when choosing a variety. These include three production traits (maturity period, yield per acre and rust resistance); two attributes related to consumption preferences (roti color and presence of zinc); and a monetary attribute, price of wheat seed. The monetary attribute included to estimate farmers' preferences for other attributes, in terms of their willingness to pay (WTP) a premium or willingness to accept a discount for the other attributes. The levels of the attributes included in the choice experiment are based on the historical data, review of the literature, and consultations with breeders at the Wheat Research Institute, Faisalabad. These attributes and their levels are explained below.

Maturity

Maturity is defined as the number of months a wheat crop takes to mature, i.e., month from emergence to maturity. We define three levels: early maturing (up to 3 and a half months); medium maturing (up to 5 months); and late maturing (up to 6 months).

Yield

The range of yield values were defined with the help of historical data and discussions with wheat breeders. Yield is measured in maund (40 kg) per acre. Three levels are identified. The yield could take the value of as high as 80 mounds per acre or as low as 30 mounds per acre or something in between, such as 50 mounds per acre.

Seed price

Based on the information on the wheat seed prices at the time, we defined three levels of price. Price could be as low as 35 Rs per kg, or as high as 60 Rs per kg or something in between such as 50 Rs per kg.

Colour of roti

Roti is flat bread made from wheat flour. . Hussain et al (2013) state that a declining zinc content in wheat flour is associated with a decline in the extraction rate. Therefore varieties with higher zinc content are expected to yield darker colour roti. Three levels of roti colour (light, medium, and dark) were presented to the respondents.

Rust resistance

Leaf and stem rust are the most destructive wheat diseases in Pakistan. We had two levels for this attribute: rust resistant or not resistant.

Zinc Content

The importance of zinc for human health was explained to the farmers. They were informed about the adverse health effects of zinc deficiency in layman terms which were developed through qualitative focus group discussions. The hyothetical wheat varieties presented had two levels of additional zinc content: yes (zinc content present) or no.These attributes, their definition and levels are presented in Table 1.

<<Table 1 here>>

Using the experimental design methods, the attributes of a wheat variety discussed above and their levels were combined into choice sets. A D-Optimal experimental design was constructed with only the main effects. The resulting efficient design contained 6 choice sets, with three attributes and a status quo option, which was choose none of the three hypothetical varieties, continue growing farmer’s current wheat variety. Information on the attribute levels of the farmers’ current varieties’ attributes were also collected. An example of a choice set is presented in Figure 1.

<<Figure 1 here>>

The respondent for the choice experiment was the head of the household. If the household head was absent the interview was conducted with another most household member who is most knowledgeable about wheat production. Prior to asking respondents to make their choices among four alternatives (A, B, C or their current variety) in the 6 consecutive choice sets, well-trained enumerators explained the attributes, their levels, and the choice exercise slowly and clearly. The enumerators asked respondents if they understood the attributes, their levels, and the choice exercise, and the enumerators repeated these definitions and instructions as many times as needed.

Enumerators also read a short “cheap talk” script, which told the respondents that even though the choices they were going to make were hypothetical in nature, we expected them to think carefully about their choices, as if they were actually going to cultivate the variety they selected in the next planting season. This script told the respondents to consider their budget constraints, the kind of food they consume and would like to consume, and their wheat variety preferences in previous planting seasons before, making their choices. As part of this script, the respondents were also told that even though their choices were hypothetical (that is, even though we would not expect them to buy the variety alternative they have selected), it was likely that the results of this study would inform delivery of certain types of wheat variety in their villages. This "cheap talk" script is expected to reduce the hypothetical bias that is inherent in stated preference studies (Carlsson, Frykblom, and Lagerkvist 2005; Chowdhury et al. 2011).

For the purpose of analysis, the attributes are coded according to their levels. The colour of roti, rust resistance, and zinc-content are codes as binary variables. Two dummy variables are defined for colour of roti (dark and medium, light is the reference category), one for rust resistance (=1 if rust resistant), and one for zinc-content (=1 if it has zinc-content). Data for yield, maturity, and price is used in cardinal-linear form. The attributes for the status-quo option (if farmers choose the variety they are currently growing) were coded with the values reported by the farmers .

4. Results

The results of the Conditional Logit Model (CLM) for the whole (pooled) sample and for each one of the farm types (marginal, small and medium and large) are reported in Table 2. For the pooled model the overall fit, as measured by McFadden's ρ^2, is 0.201. Values of ρ^2 between 0.2 and 0.4 are considered to be extremely good fits for probabilistic discrete choice models (Hensher, Rose, and Greene, 2005). The positive and significant value of alternative specific constants (ASCs) indicate that farmers have a general preference for alternate choices over the status quo. The coefficients are statistically significant and intuitively correct. This implies the importance of all the attributes in determining the wheat varietal choice. Farmers are more likely to choose the varieties that are early maturing, higher yielding, cheaper, and rust resistant. The negative and significant coefficient of the dummy variables indicating the colour of roti show farmers' preference for a variety that can give light coloured roti over dark and medium coloured roti. A highly positive and significant coefficient of the dummy variable representing zinc content reveals that farmers prefer to have those wheat varieties which contain zinc. In fact among the dummy variables, having zinc content has the highest coefficient, i.e., the biggest effect on a hypothetical variety being chosen, revealing the importance of this attribute on farmer choice of a variety.

<<Table 2 here>>

As discussed earlier, the data were collected from three agro-climatic zones of irrigated Punjab, from farmers with varying sizes of areas under wheat cultivation. Based on cultivated wheat area we group farm sizes into three categories : marginal (cultivate up to 5 acres), small-scale (cultivate up to 12.5 acres but more than 5 acres), and medium-large scale (cultivated land is greater than 12.5). Most wheat farms (71%) belong to the marginal and small-scale categories. It is also useful to look at the differences across these agro-climatic zones which may represent different production and consumption preferences.

Table 2 also presents the results of CLM for the three different farm sizes. Swait-Louviere log likelihood ratio test rejects the null hypothesis that the regression parameters are equal at 0.5% significance level. Therefore it can be concluded that farmers with different farm sizes have distinct preferences for wheat attributes, compared to the pooled model.

The results reveal that the main differences across the farmers with different farm sizes are (i) importance of maturity, (ii) imporrtance of seed price, (iii) preferences for roti colour, and (iv) relative importance of zinc attribute. The coefficient on maturity is insignificant for marginal and small-scale farmers. This could be explained by the fact that marginal and small-scale farmers grow wheat with other major crops (e.g., cotton and rice) in rotation. The harvest of cotton crop is completed in November and some farmers extend it up to December. Such farmers prefer late maturing wheat varieties. Because of larger farm size, medium and large-scale farmers can grow wheat on time while keeping some of the cotton crop in field..The coefficient on seed price attribute is a significant determinant of choice only for farmers who farm marginal areas. For small-scale and medium and large scale farmers, wheat seed price is not a significant determinant of choice. This could be because farmers who manage marginal size farms have significantly more pressing budget constraints compared to their small and medium to large scale counterparts. In terms of roti colour, all farmers prefer the light colour roti, hence we observe negative and significant coefficients on the dark and medium colour rotis.

Small-scale farmers, however, are indifferent between the medium and dark colour roti, whereas marginal and medium and large size farmers dislike dark coloured roti significantly more than medium colour roti, which is even more pronounced for the medium and large scale farmers. The latter could be explained by the fact that medium and large scale farmer sell a significantly great;er proportion of their wheat harvest, and they would not be fetching higher prices in the market if their variety was producing darker coloured roti. Finally, even though farmers of all sizes prefer wheat varieties with zinc content, this is not the most important attribute of wheat variety choice for medium to large scale farmers. This could be because of the fact that compared to the marginal and small scale farmers, medium and large scale farmers sell a majority of their output, and they would be unable to capture higher prices for wheat varieties that have invisible traits, such as the benefit of having higher wheat content.

To capture the effect of agro-climatic zones on farmer preferences of wheat attributes, we estimated seperate CLMs for farmers with different farm sizes in each one of the three agro-climatic zones. Results are reported in Table 2. For each one of the farm size types, Swait-Louviere log likelihood ratio test rejects the null hypothesis that the regression parameters for different agro-climatic zones are equal at 0.5% significance level. Therefore it can be concluded that farmers with the same farm sizes but in different agro-climatic zones have distinct preferences for wheat attributes.

<<Table 3 here>>

Across all three zones, marginal size farmers prefer wheat varieties that are higher yielding and resistant to rust. Maturity is not a significant determinant of wheat variety choice for marginal farmers in any of the three zones. Marginal size farmers in cotton-wheat and rice-wheat zones prefer wheat varieties with zinc content. In fact for these marginal size farmers zinc content is the most important and significant determinant of wheat variety choice among the binary attributes. Zinc content is however not a significant determinant of varietal choice for marginal size farmers in the mixed zone. Marginal size farmers in the rice-wheat zone prefer wheat varieties that have cheaper seed prices, whereas those in the mixed zone prefer varieties with higher prices, perhaps considering higher price to be an indicator of high quality. Although expected sign, wheat seed price does not significantly effect the marginal size farmers' choice of wheat varieties in the cotton-wheat zone. Finally, there are significant differences in marginal sized farmers' preferences for roti colour across the study zones. Marginal farmers in cotton-wheat zone, are indifferent to the colour of the roti, whereas those in the other two zones prefer light colour roti to medium and dark coloured ones. Even though marginal size farmers in the rice-wheat zone derive similar levels of disutility from medium and dark colour roti, those in the mixed zone dislike dark coloured roti significantly more than they dislike the medium coloured roti.

Small-scale farmers across all three zones prefer wheat varieties that are higher yielding. Maturity is a significant determinant of wheat variety choice for small-scale farmers in the mixed zones, with those farmers prefering earlier maturing varieties. Similarly to the marginal size farmers, small-scale farmers in cotton-wheat and rice-wheat zones prefer wheat varieties with zinc content. In fact, as with the marginal size farmers, for these small-scale farmers farmers zinc content is the most important and significant determinant of wheat variety choice among the binary attributes. Zinc content is however not a significant determinant of varietal choice for small-scale size farmers in the mixed zone. Again similarly to the marginal size farmers, small scale farmers in the rice-wheat zone prefer wheat varieties that have cheaper seed prices, whereas those in the mixed zone prefer varieties with higher prices. Although expected sign, wheat seed price does not significantly effect the small-scale farmers' choice of wheat varieties in the cotton-wheat zone. There are also significant differences in small farmers' preferences for roti colour across the study zones. Small-scale farmers in cotton-wheat zone are indifferent to the colour of the roti, whereas those in the other two zones prefer light colour roti to medium and dark coloured ones. Small-scale farmers in the rice-wheat zone derive significantly higher levels of disutility from medium colour roti, compared to the dark one, whereas those in the mixed zone dislike dark coloured roti slightly more than they dislike the medium coloured roti. Rust resistance is a significant determinant of wheat variety choice for small-scale farmers in cotton-wheat and rice –wheat zones, however is not a determinant factor for small-scale farmers' varietal choice in the mixed zone.

Finally, across all three zones, medium and large scale farmers prefer wheat varieties that are higher yielding. As with the other two farm size types, maturity is not a significant determinant of wheat variety choice for medium and large scale farmers in any of the three zones. Medium and large scale size farmers in cotton-wheat and rice-wheat zones prefer wheat varieties with zinc content. In fact for these medium and large scale farmers zinc content is the most important and significant determinant of wheat variety choice among the binary attributes. Zinc content is however not a significant determinant of varietal choice for medium and large scale farmers in the mixed zone. These results about zinc preferences are similar to those for smaller-scale farmers in the same zones. Medium and large scale farmers in the cotton-wheat and rice-wheat zones prefer wheat varieties that have cheaper seed prices, whereas those in the mixed zone prefer varieties with higher prices, as with their smaller scale counterparts in this zone. There are some differences in marginal sized farmers' preferences for roti colour across the study zones. Medium and large scale farmers in cotton-wheat zone, are indifferent between light and medium coloured roti, whereas they dislike dark coloured roti. Medium and large scale farmers in the other two zones prefer light colour roti to medium and medium roti to dark coloured ones. The medium and large scale farmers in the mixed zone dislike dark coloured roti significantly more than they dislike the medium coloured roti. Finally, rust resistance is a significant determinant of wheat variety choice for medium and large scale farmers in rice –wheat and mixed zones, however is not a determinant factor for medium and large scale farmers' varietal choice in the cotton-wheat zone.

5. Conclusions and Policy Implications

To address the issue of zinc-deficiency in Pakistan, the Government of Pakistan aims to introduce the zinc-biofortified wheat varieties by the end of 2015. Given the fact that a large proportion of wheat farmers use either saved/exchanged seed or purchase from informal sources, such as, input dealers, shopkeepers and large landlords, acceptability and adoption of zinc-biofortified varieties is a big challange for the policy makers and private sector alike. To develop varieties that meet farmer preferences as well as to design effective programs for the marketing and delivery of zinc-biofortified varieties, especially to small farmers, the Government of Pakistan and the private sector need to understand the factors that affect farmeracceptance, adoption, and diffusion of zinc-biofortified wheat varieties. Using the stated preference choice experiment method, this study provides a timely analysis of the varietal attributes that farmers of different sizes and in different agro-climatic zones prefer s. Such information would be helpful in breeding zinc-biofortified wheat varieties suitable for different types of farmers in different locations and designing effective and targeted delivery and marketing mechanism for these varieties.

To conduct choice experiment on wheat farmers, six attributes were identified. These include: yield, maturity period, resistant to rust, presence of zinc content, and colour of the roti (flat bread). In addition, to estimate farmers' willingness to pay (WTP) we included a monetary attribute, i.e., price of wheat seed. The choice experiment data were collected through interviews with 1116 wheat farmers during October-November 2011 in 3 agro-climatic zones (rice-wheat, cotton-wheat, and mixed zones).

We analyze the data using the conditional logit model (CLM) for the entire sample of 1116 farmers, and also for subsamples that take farm size/type (marginal, small-scale, and large and medium) and agro-climatic zone into consideration. The results of pooled CLM show that farmers are more likely to choose the varieties that are early maturing, higher yielding, cheaper, and rust resistant. In addition, farmers' preference for light coloured roti is very strong. A highly positive and significant coefficient of the dummy variable representing zinc content reveals that farmers prefer to have those wheat varieties which contain zinc.

We found significant differences in farmers' preferences for wheat varietal attributes across farm types and agro-climatic zones. Across farm types, main differences from the pooled model are that (i) maturity is an important factor in wheat variety choice especially for medium and large scale farmers, who prefer varieties that are early maturing; (ii) seed price is an important determinant of variety choice only for marginal farmers, who prefer varieties with cheaper seed price; (iii) even though farmers of all types prefer light coloured roti, dislike for dark coloured roti is much more pronounced for medium and large scale farmers, and finally (iv) even though farmers of all types prefer varieties with zinc content, this attribute is a more important factor in the varietal choice of marginal and small-scale farmers.

When agro-climatic location of these farmers are taken into consideration, we find that (i) farmers of all types in all three zones prefer higher yielding varieties, (ii) farmers of all types in all three zones prefer rust resistant varieties except for small-scale farmers in mixed zone and medium and large scale farmers in cotton-wheat zone. These results reveal that overall higher yielding and rust resistant zinc-biofortified varieties would be easily accepted and adopted by farmers in all areas. (iii) In most cases seed price has the expected negative sign, revealing that farmers prefer cheaper seeds, except in some cases the prive attribute is insignificant (e.g., for marginal and small-scale farmers in cotton-wheat zone) and in others its positive and significant (e.g., for all types of farmers in the mixed zones). High prices might be considered to mean high quality seeds, therefore prices of zinc biofortified varieties need to be set such that they are not too high to discourage some farmers from adopting these varieties, and they are not so low that they do not signal quality; (iv) overall marginal and small-scale farmers in the cotton-wheat zone are indifferent between the roti colours, and medium and large scale ones in the same zone only dislike dark coloured roti. In the other two zones, farmers of all types dislike medium and dark coloured roti, and disutility associated with dark roti is epecially higher for those in the mixed zone. These results reveal that for acceptance, especially in rice-wheat and mixed zones, breeders have to ensure the colour of wheat and wheat products do not change with zinc biofortification. Finally (v) in cotton-wheat and rice-wheat zones farmers of all sizes prefer varieties with zinc content, in fact this attribute is the most important determinant of varietal choice among the binary attributes. In mixed zone, however, zinc content is not a significant determinant of varietal choice, revealing that additional awareness/social marketing campaigns will need to be implemented for zinc-biofortified varieties to be accepted and adopted in this zone.

Tables and Figures

Table 1: Attributes and their definitions and levels of wheat variety evaluated

Attribute	Definition	Levels
Maturity	Months from planting to harvesting	3.5, 5, 6
Yield	Quantity harvested in maunds (40 kg/acre)	30, 50, 80
Seed price	Price of wheat seed (Rs/kg)	35, 50, 60
Colour of roti	Colour of roti (flat bread made from wheat flour)	Light, medium, dark
Rust resistant	If variety is rust resistant or not	Rust resistant or not
Zinc	If variety has zinc	Yes, No

Table 2: Conditional Logit Model Estimates by Farm Size

VARIABLES	Model 1: Base Model	Marginal farm size	Small farm size	Medium & large farm size
Maturity (months)	-0.067**	-0.053	-0.065	-0.080*
	(0.027)	(0.045)	(0.048)	(0.049)
Yield (40 kg/acre)	0.045***	0.044***	0.047***	0.045***
	(0.002)	(0.003)	(0.003)	(0.003)
Seed price (Rs/kg)	-0.005**	-0.007**	-0.003	-0.006
	(0.002)	(0.004)	(0.004)	(0.004)
Dark (=1 if Roti color is dark)	-0.410***	-0.512***	-0.478***	-0.825***
	(0.063)	(0.078)	(0.081)	(0.094)
Medium (=1 if Roti color is medium)	-0.584***	-0.360***	-0.483***	-0.376***
	(0.048)	(0.107)	(0.105)	(0.116)
Rust (=1 if rust resistant)	0.276***	0.302***	0.301***	0.215***
	(0.043)	(0.073)	(0.074)	(0.081)
Zinc (=1 if Zinc content)	0.881***	0.804***	1.026***	0.812***
	(0.046)	(0.077)	(0.081)	(0.083)
ASC Wheat Seed A	0.990***	1.130***	0.703***	1.173***
	(0.110)	(0.190)	(0.182)	(0.201)
ASC Wheat Seed B	1.159***	1.389***	0.867***	1.232***
	(0.105)	(0.182)	(0.174)	(0.193)
ASC Wheat Seed C	0.549***	0.773***	0.213	0.679***
	(0.122)	(0.210)	(0.204)	(0.225)
Observations	26,784	9,408	9,552	7,824
Log likelihood	-6589.78	-2352.36	-2307.77	-1915.14
Pseudo R2	0.20	0.19	0.22	0.20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 3: Conditional Logit Model Estimates by Farm Size across Agro-climatic Zones

	Marginal Farm size			Small Farm size			Medium & Large Farm size		
VARIABLES	Cotton-wheat zone	Rice-wheat zone	Mixed zone	Cotton-wheat zone	Rice-wheat zone	Mixed zone	Cotton-wheat zone	Rice-wheat zone	Mixed zone
Maturity (months)	-0.024	0.002	-0.099	0.013	-0.056	-0.237**	-0.048	-0.063	-0.157
	(0.067)	(0.110)	(0.081)	(0.068)	(0.120)	(0.092)	(0.068)	(0.129)	(0.104)
Yield (40 kg/acre)	0.042***	0.071***	0.037***	0.054***	0.064***	0.023***	0.039***	0.075***	0.042***
	(0.004)	(0.006)	(0.006)	(0.004)	(0.006)	(0.007)	(0.004)	(0.007)	(0.007)
Seed price (Rs/kg)	-0.009	-0.020**	0.018**	-0.000	-0.020***	0.030***	-0.012**	-0.028***	0.032***
	(0.006)	(0.008)	(0.007)	(0.005)	(0.008)	(0.008)	(0.006)	(0.010)	(0.008)
Dark (=1 if Roti color is dark)	0.054	-0.561***	-1.704***	-0.183	-0.341*	-1.530***	-0.484***	-0.838***	-1.903***
	(0.112)	(0.182)	(0.178)	(0.119)	(0.174)	(0.188)	(0.128)	(0.221)	(0.211)
Medium (=1 if Roti color is medium)	0.063	-0.457**	-0.863***	-0.066	-0.905***	-1.288***	-0.173	-0.556**	-0.734***
	(0.161)	(0.227)	(0.212)	(0.153)	(0.229)	(0.254)	(0.167)	(0.269)	(0.237)
Rust (=1 if rust resistant)	0.298***	0.441***	0.264*	0.191*	0.442***	0.093	0.087	0.440**	0.301*
	(0.107)	(0.161)	(0.143)	(0.108)	(0.156)	(0.158)	(0.114)	(0.187)	(0.166)
Zinc (=1 if Zinc content)	0.999***	1.612***	-0.054	1.285***	1.882***	-0.127	0.866***	1.660***	0.107
	(0.119)	(0.194)	(0.139)	(0.125)	(0.217)	(0.154)	(0.122)	(0.227)	(0.164)
ASC Wheat Seed A	0.635**	1.004***	1.583***	-0.374	1.112***	3.218***	0.950***	1.476***	0.968**
	(0.308)	(0.385)	(0.390)	(0.274)	(0.376)	(0.786)	(0.295)	(0.479)	(0.417)
ASC Wheat Seed B	1.172***	0.894**	1.809***	-0.083	1.195***	3.306***	1.167***	1.339***	1.015**
	(0.298)	(0.352)	(0.374)	(0.263)	(0.347)	(0.775)	(0.283)	(0.432)	(0.397)
ASC Wheat Seed C	0.607*	0.424	0.628	-0.667**	0.792**	1.886**	0.815**	1.150**	-0.613
	(0.331)	(0.429)	(0.446)	(0.300)	(0.402)	(0.830)	(0.318)	(0.526)	(0.488)
Observations	3,624	3,072	2,712	4,056	3,144	2,352	3,264	2,424	2,136
Log likelihood	-1001.21	-598.60	-625.53	-1047.59	-590.65	-517.33	-879.59	-445.62	-488.36
Psedu R2	0.13	0.36	0.19	0.21	0.37	0.17	0.15	0.39	0.20

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 1: Example of a choice set

WHEAT SEED CHARACTERISTICS	WHEAT SEED A	WHEAT SEED B	WHEAT SEED C	MY CURRENT SEED D
MATURITY (DAYS)	5 MONTHS MID MATURITY 16 TO 25 NOVEMBER — APRIL	6 MONTHS LATE MATURITY UP TO 15 NOVEMBER — APRIL	3.5 MONTHS EARLY MATURITY 26 NOVEMBER TO DECEMBER — APRIL	I LIKE NEITHER A NOR B NOR C. I PREFER TO CONTINUE TO CULTIVATE THE VARIETY I CULTIVATED THIS PAST WHEAT SEASON
YIELD (Monds/ACRE)	30	50	30	
SEED PRICE(PRICE/KG)	60	35	50	
ROTI COLOUR	DARK	LIGHT	DARK	
NUTRITIOUS	ZINC NO	ZINC YES	ZINC NO	
RUST RESISTANCE	YES	NO	NO	

References

Banerji, A., Chowdhury, S., De Groote, H., Meenakshi, J.V., Tomlins, K., Haleegoah, J., & Ewool, M. 2013. Using Elicitation Mechanisms to Estimate the Demand for Nutritious Maize: Evidence from Experiments in Rural Ghana. *HarvestPlus Working Paper 10*.

Banerji, A., Birol, E., Karandikar, B., & Rampal, J. 2015. Information, Branding, Certification and ConsumerWillingness to Pay for High-Iron Pearl Millet: Evidence from Experimental Auctions in Maharashtra, India. HarvestPlus Working Paper 17.

Bateman, I.J., Carson, R.T., Day, B., Hanemann, W.M., Hanley, N., Hett, T., Jones-Lee, M., Loomes, G., Mourato, S., Ozdemiroglu, E., Pearce, D.W., Sugden, R. and Swanson, S. 2003. "Guidelines for the Use of Stated Preference Techniques for the Valuation of Preferences for Non-market Goods", Edward Elgar, Cheltenham.

Ben-Akiva, M. and S. R. Lerman. 1985. Discrete Choice Analysis, Theory and Application to Travel Demand, MIT Press, Cambridge Massachusetts.

Birol, Ekin, J. V. Meenakshi, Adewale Oparinde, Salomon Perez and Keith Tomlins. 2015. Developing country consumers' acceptance of biofortified foods: a synthesis. Food Security 7:555–568

Boxall, Peter C. and Wiktor L. Adamowicz. 2002. “Understanding Heterogeneous Preferences in Random Utility Models: A Latent Class Approach,” Environmental and Resource Economics, 23(4), 421–46.

Carlsson, Fredrik, Peter Frykblom, and Carl J. Lagerkvist. 2005. “Using CheapTalk as a Test of Validity in Choice Experiments,” Economics Letters, 89(2), 147–52.

Chowdhury, Shyamal, J. V. Meenakshi, Keith I. Tomlins, and Constance Owori. 2011. “Are Consumers in Developing Countries Willing to Pay More for Micronutrient-Dense Biofortified Foods? Evidence from a Field Experiment in Uganda,” American Journal of Agricultural Economics, 93(1), 83–97.

Government of Pakistan, 2011. Agriculture Statistics of Pakistan 2010-11. Ministry of Food and Agriculture, Islamabad

Greene, William H. 2008. Econometric Analysis (Sixth Edition). New York: Prentice Hall.

Greene, William H. and David A. Hensher. 2003. “A Latent Class Model for Discrete Choice Analysis: Contrasts with Mixed Logit,” Transportation Research, Part B: Methodological, 37(8), 681–98.

Hanley, N., R.E. Wright and W.L. Adamowicz. 1998. “Using Choice Experiments to Value the Environmental”, Environmental and Resource Economics, 11 (3-4): 413-428.

Hussain, Akhlaq. 2011. Status of Seed Industry in Pakistan. Paper Presented at the Round Table Discussion on “Agriculture and Water in Pakistan”. Government of Pakistan

Hussain, S., M.A. Maqsood, Z. Rengel, T. Aziz and M. Abid. 2013. Estimated zinc bioavailability in milling fractions of biofortified wheat grains and in flours of different extraction rates. International Journal of Agriculture & Biology. 15: 921–926

Kontoleon, A. 2003. Essays on non-market valuation of environmental resources: policy and technical explorations, Ph.D. Thesis, University College London, University of London.

Lancaster, K. J. 1966. “A New Approach to Consumer Theory,” Journal of Political Economy, 74(2), 132–57.

Luce, R. Duncan. 1959. Individual Choice Behavior. New York: John Wiley.

Maddala, G. S. 2001. Introduction to Econometrics (Third edition). Saddle River, NJ: Prentice Hall.

Malik, S. J., Hina Nazli and Edward Whitney (2014). "The Official Estimates of Poverty in Pakistan – what is wrong and why? – Illustrations using the Government of Pakistan's Household Integrated Economic Survey 2010-11". PSSP Working Paper (forthcoming), Pakistan Strategy Support Program of International Food Policy Research Institute: Islamabad.

McFadden, Daniel. 1974. "Conditional logit analysis of qualitative choice behavior," in Frontiers in Econometrics, Paul Zarembka, ed. New York: Academic Press, 105-42.

Meenakshi, J. V., Nancy, J., Manyong, V., De Groote, H., Javelosa, J., Yanggen, D., Naher, F., Garcia, J., Gonzalez, C., & Meng, E. 2010. How Cost-Effective is Biofortification in Combating Micronutrient Malnutrition? An ex ante Assessment. *World Development*, 38(1), 64–75.

Meenakshi, J.V., Banerji, A., Manyong, V., Tomlins, K., Mittal, N., & Hamukwala, P. 2012. Using a Discrete Choice Experiment to Elicit the Demand for a Nutritious Food: Willingness-to-Pay for Orange Maize in Rural Zambia. *Journal of Health Economics*, 31, 62-71.

National Nutrition Survey. 2011. National Nutrition Survey of Pakistan, Islamabad: Government of Pakistan, Aga Khan University and UNICEF

Nazli, Hina, Dorene Asare-Marfo, Melinda Smale, Sohail Jehangir Malik, Ekin Birol. 2014. Smallholder Farming and Crop Variety Choice: Wheat Variety Choice in Pakistan. Research for Action # 2. HarvestPlus. Washington, D. C.

Oparinde, A., Banerji, A., Birol, E., & Ilona, P. Forthcoming. Information and Consumer Willingness to Pay for Biofortified Yellow Cassava: Evidence from Experimental Auctions in Nigeria. *Agricultural Economics*.

Oparinde, A., Ekin Birol, Abdoul Murekezi, Lister Katsvairo, Michael T. Diressie, Jean d'Amour Nkundimana and Louis Butare. 2015. Consumer Acceptance of Biofortified Iron Beans in Rural Rwanda: Experimental Evidence. HarvestPlus Working Paper 18.

Saltzman, A., Birol, E., Bouis, H., Boy, E., Moura, F., Islam, Y., & Pfeiffer, W. 2013. Biofortification: Progress toward a more nourishing future. *Global Food Security*, 2(1), 9-17.