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Farmers' valuation of transgenic biofortified sorghum for nutritional improvement in Burkina Faso: A latent class approach

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ABSTRACT

Micronutrient malnutrition has been a challenge in Burkina Faso for many years, where it has led to worsening food security situation. Vitamin, iron and zinc deficiencies affects 1 in 4 persons in the country and is responsible for early child nutritional disorder. The high prevalence of micronutrient malnutrition may be attributed to the dominant role in the diet of local sorghum varieties, deficient in essential micronutrients. To address this issue Africa Harvest is developing a biofortified sorghum variety. However the success of this innovation with farmers will depend on numerous factors such as product attributes, previous experience and socioeconomic factors. In this study, we applied a choice experiment to investigate the farmers' valuation of various sorghum seed attributes as well as to identify the factors that influence the farmers valuation. Our results show that there is a market for transgenic biofortified food in the country and thus that it could be a veritable instrument for reducing micronutrient malnutrition problems. We found that farmers are willing to pay more for biofortified sorghum, particularly if it also scores better on other attributes than the local varieties. Furthermore, we showed that those that have experience with the first-generation genetic modified crop (Bt cotton), are more likely to adopt the second-generation crop (biofortified sorghum). Given the importance of the other attributes and the heterogeneous preferences it is key to involve farmers in the development of the new product.

1. Introduction

Micronutrient malnutrition (MNM) is an important contributor to the global burden of diseases (International Food Policy Research Institute, IFPRI, 2016). It has been a challenge in Burkina Faso for many years, where it has led to worsening food security situation (World Food Programme, 2017). MNM in form of vitamin, iron and zinc deficiencies affects 1 in 4 persons in the country (FAO, 2014). A UNICEF report showed that while 34% of the country's population are chronically malnourished, above 10% suffers from acute malnutrition (UNICEF, 2013). Furthermore, another report showed that Burkina Faso has a very high level of infant mortality rate, averaging at 129 per 1000 livebirth, with 34.6% of children being stunted and 25.7% underweight (IFPRI, 2015).

The high prevalence of MNM in Burkina Faso may be attributed to its location in an arid region where the climatic and soil conditions are unfavourable for sustainable cultivation of highly nutritious food (Li et al., 2012; Miller and Welch, 2013; Obi et al., 2017). For instance, it was found that the local sorghum cultivar, the most important staple crop, is deficient in essential micronutrients (da Silva et al., 2011; Paiva et al., 2017; Traore and Stroosnijder, 2005). Therefore, by continuously consuming this starchy crop, the nutritional needs of the rural poor are not met.

The initiative to improve the nutritive content of the local sorghum cultivar through biotechnology was taken by Africa Harvest International (AHI) in 2001. The project was funded under the Grand Challenges in Global Health initiative by the Bill and Melinda Gates Foundation. The resulting African Biofortified Sorghum (ABS) would contain increased levels of vitamin A, Iron, and Zinc (AHBFI, 2007).

Nevertheless, for a new biofortified crop to achieve success in reducing the problem of MNM in the country, it must be highly valued by the rural poor. This can only be possible, however, if the dissuading factors are eliminated. First, transgenic biofortification as the second generation of genetic modification (GM) projects is still in its early stage of development (De Steur et al., 2017), yet it is mired with strong controversies. These controversies may play an important role in the

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adoption decision of farmers (Adenle et al., 2013). Second, biofortification in general tends to alter the sensory attributes of crops such as taste, fragrance and colour (De Groote et al., 2014). These changes have been found to deter the acceptance of non-transgenic biofortified crops in many developing countries (Banerji et al., 2016; De Steur et al., 2012).

In Burkina Faso, aside from the GM controversies and the possible changes in product attributes, the local food culture is another factor that can play a role in the farmers' adoption. In earlier attempts to introduce improved sorghum varieties with better agronomic attributes, studies have shown that the farmers kept preferring their local sorghum cultivar (Adesina and Baidu-Forson, 1995; Olembo et al., 2010). Issues relating to perceived superiority of the attributes of local cultivars, penchant to seed saving culture, and transaction costs were identified. Although a noticeable adoption level was later reported, thanks to the introduction of the participatory sorghum breeding project. Nonetheless, the recorded improvement is only pronounced in the project areas whereas adoption of improved varieties at the national level is still as low as 3–5% (CIRAD, 2016).

The new transgenic biofortified variety is being produced to provide an additional nutritive attribute that is not available in either the improved variety nor the local varieties. Following Saltzman et al. (2013), we hypothesize that farmers will not only consider the nutritive value of the biofortified variety, but also the agronomic and economic attributes when making adoption decision. Therefore, the objective of this research is to determine the market potential of the transgenic biofortified sorghum in the country. To achieve this, we estimated the farmers' valuation, or rather the welfare drawn from hypothetical attributes of the biofortified variety. Furthermore, we examined how their socioeconomic characteristics, experiences, local practices, and motivations influence their valuation of the new variety, and calculated the farmers willingness to pay for attribute changes.

The study contributes to the existing literature in market potential of transgenic biofortified crop in twofold. First, the Discrete Choice Experiment (DCE) methodology used in the study is quite unique. Most ex ante studies conducted on farmers' choice for transgenic crops use contingent valuation presenting a dichotomous choice between a transgenic variety and a non-transgenic variety (Hubbell et al., 2002; Krishna and Qaim, 2007; Qaim and de Janvry, 2003). This method has been subjected to criticisms in terms of its ability to deliver reliable and accurate estimates (Mogas et al., 2006). For instance, Hanley et al. (2001) observed that the approach is not suitable to deal with cases where attributes valuations are multidimensional. Furthermore, compared to other related DCE studies which used multinomial logit model (Birol et al., 2007; Breustedt et al., 2008; Schreiner, 2014), our study is different because it accounts for farmers' preference heterogeneity.

Different models of DCE that can account for unobserved heterogeneity as well as potential source of variabilities in decision makers' preference have been contrasted by Greene and Hensher (2003). Considering the three possible alternatives (parametric mixed logit model, random parameter latent class model, and the semi-parametric latent class model), Kikulwe et al. (2011) posited that when the objective is to segment a population based on the welfare derived from a new technology, a semi-parametric latent class model (LCM) is most relevant from a policy perspective. Therefore, by using this LCM, we were able integrate a wide spectrum of product alternatives and covariate parameters that segmented our respondents based on homogeneous characteristics within, and heterogeneous across. Segmentation is a very useful marketing strategy to identify different categories of farmers and how they value a product.

Secondly, the addition of the seed source attribute to the DCE is innovative. Arguments have been put forward on how the source of transgenic seeds and their distribution conditions influence farmers' adoption. For example, while Mabaya et al. (2015) stated that the potential of transgenic crops to improve nutritional security in Sub-Saharan Africa (SSA) depends to a large extent on the farmers' access to the seed, Andekelile and Leon (2016) added that the conditions on which seeds are distributed are vital, and should harmonise with farmers' experience and practices. Seed saving practice might lead to low adoption of new transgenic crop varieties, specifically if new seeds are protected by intellectual property rights and seed reuse restriction conditions applies (Black et al., 2010). Furthermore, when the rural poor farmers are obliged to purchase the transgenic seeds every planting season, the traditional seed exchange behaviours may be disturbed, thereby greatly affecting the market of transgenic seeds (Azadi et al., 2015; Garcia-Yi et al., 2014). While these arguments have always resurfaced in many GM debates, the degree to which the seed source and distribution conditions influences farmer's preference for transgenic biofortified seeds was never captured in a DCE.

The rest of the paper is structured as follow: in Section 2, the Choice experiment method is presented, starting with the theoretical framework. This is followed by the description of the choice experiment design and data sampling method. The results and discussions come afterwards in Section 3, then the conclusion and recommendations follow in Section 4.

2. Choice experiment method

2.1. Theoretical framework

Choice models are based on the theory of individual choice behaviour which captures the farmers' preference for attributes that make up a product (Louviere et al., 2008). It has its theoretical origin in Lancaster's' model of consumer choice (Lancaster, 1966), and the theory of Random Utility. Lancaster stated that satisfaction will be obtained from the attributes of a product rather from the product itself, while Random utility observed people to be rational and as such, when presented with two or more options, they would likely decide in favour of the one providing them with higher utility. To elicit the preference of an individual from a set of alternatives, a DCE is often applied. As a stated preference elicitation method, DCE is appropriate when a product is new and/or not yet commercially available (Louviere et al., 2000; Lindsay et al., 2009). Unlike the revealed preference method, stated preference methods give the researcher the room to include hypothetical attributes which might not be available in alternative products that are already in the market.

The LCM is one of the econometric models that can be used to analyse DCE data The LCM simultaneously identifies subgroups having homogenous preferences for an attribute and the characteristics which these groups have in common. It assumes that individuals reside in 'latent' classes which are unknown to the analyst, with each class having a homogenous preference structure. Classes, otherwise referred as segments in this article, are often determined by the socio-economic characteristics of the respondents and choice of product attribute. In related literature on transgenic crop market research, a LCM was applied by Birol et al. (2011), Kikulwe et al. (2011) and Birol et al. (2007). In the latter two studies, motivational questions concerning farmers' knowledge, perception and attitude towards the transgenic food were included to segment membership structure. It was observed in all the studies that a significant heterogeneity exists in respondents' preference for transgenic foods. The result is particularly important in market segregation and targeting. For instance, in Uganda, Kikulwe et al. (2011) observed that the biofortified banana should be a pro-poor programme targeting rural farmers. Therefore, by applying LCM in our study, we can provide relevant information to policy makers and product developers for product development and marketing strategy.

Following the econometric model specification proposed by Greene and Hensher (2003), before the LCM, a Conditional Logit (CL) may first be specified. While the CL presents a holistic preference of all respondents, the LCM gives a segmented preference structure. The general econometric model consists of parameterized utility functions $U_{nij/s}$ in terms of observable independent variables $\beta_s X_{nij}$ and unknown