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Control of vegetable pests in Benin – Farmers' preferences for eco-friendly nets as an alternative to insecticides

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ABSTRACT

We investigated if eco-friendly nets (EFNs) are a viable and acceptable alternative to extremely high levels of insecticide use in vegetable production. Using a choice experiment, we found that vegetable producing farmers in Benin preferred all of the characteristics of EFNs except the higher labor requirements. The nets had been distributed in a trial phase for free but in the long run farmers would need to purchase the EFNs. The break-even point for investing in nets was found to vary with the lifespan of EFNs, their purchase price and potential health benefits from avoiding large quantities of insecticides. To break even the nets need to be used for at least two production cycles. To overcome risk-averse farmer's reluctance to adopt EFNs we propose a credit and warranty scheme along with the purchase of the nets. The study's findings can guide the implementation of EFNs in other African countries as part of integrated pest management with global benefits for the environment and human health.

1. Introduction

Continuing growth in human population and consumption means that the global demand for food will increase for at least another 40 years (Godfray et al., 2010) and that the world need 70–100% more food by 2050 (World Bank, 2008). More than one in seven people today still do not have access to sufficient protein and energy from their diet, and even more suffer from some form of micronutrient malnourishment (Barrett, 2010). Increasing urbanization and climate change aggregates food insecurity. The urban population expansion is more pronounced in developing countries as a result of rural-to-urban migration and natural population growth (FAO, 2007). By 2030, over half of Africa's population will reside in urban areas, augmenting the 'invisible crisis' of urban food security (Crush and Frayne, 2010).

Smallholder farmers can play an important role in supplying urban markets and meeting the food demand of growing urban centers (FAO, 2007, 2012). In Sub-Saharan Africa (SSA) vegetables have been growing in importance both as food for city dwellers and for generating and diversifying income for smallholder farmers (Weinberger and Lumpkin, 2007; World Bank, 2008). In urban areas farmers use public open spaces (e.g. along roads, power lines, drains and streams) to cultivate vegetables commercially for the local market (Drechsel and Dongus, 2010; Crush et al., 2011; Dossa et al., 2011; FAO, 2012; Probst et al., 2012a), often in groups, though not necessarily working together (Jacobi et al., 2000). However, fruit and vegetable consumption in SSA remains low and currently

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contributes at most 82%, and sometimes as low as 22%, of the daily intake recommended by the World Health Organization and Food and Agricultural Organization (Nair and Ngouajio, 2010).

One impediment to boosting vegetable production in SSA is, besides the competition for fertile land, water and energy, high exposure to pests and diseases (MEA, 2005; Waterfield and Zilberman, 2012). Globally, food estimated to feed an additional one billion people is lost to pests (Birch et al., 2011). In Benin, for instance, insects cause an average yield loss of 30–40% (Matthews, 2008).

To counter pests, farmers in Benin rely heavily on synthetic pesticides to reduce the risk of harvest and income loss, particularly to protect exotic crops like cabbage and lettuce (Williamson et al., 2008; Lund et al., 2010; Ahouangninou et al., 2012, 2013). Such heavy pesticide use not only results in high levels of human exposure and poisoning (Williamson, 2005; Ntow et al., 2006) but also reduces the quality of aquatic and terrestrial ecosystems, contaminating drinking water and food crops (Pimentel et al., 1992; van der Werf, 1996). Smallholder farmers often use pesticides with little understanding of their impact on human health and the environment (Matthews, 2008) and inappropriate knowledge on safe handling, storing and applying pesticides (Williamson, 2005; Ngowi et al., 2007; Ahouangninou et al., 2012; Amoabeng et al., 2014; de Bon et al., 2014). Farmers also often ignore, or are unaware of, regulations issued by the Benin government for the distribution and use of pesticides (Présidence de la République du Benin, 1991) and assume that the only solution to pest control is to increase dose and spray frequency (Martin et al., 2006). Such overuse of hazardous pesticides both increases resistance of pests and destroys beneficial predators (Clarke, 1997; Wilson and Tisdell, 2001; Ntow et al., 2006; Lund et al., 2010; Probst et al., 2012b).

According to Probst et al. (2012a), without changing pest control strategies and efficient governmental control mechanisms, urban vegetable production in the cities will remain in a state of "systemic rigidity". A potential means to break the reliance on pesticides is a form of sustainable and integrated pest management (IPM) that is affordable and accessible to all farmers (Tokannou and Quenum, 2007; Hounguè and Kindomihou, 2009) combined with practices that intensify production through carefully managed inputs of fertilizer and water (Herrero et al., 2010).

One approach to IPM can be physical exclusion of pests using eco-friendly nets (EFNs). EFNs were introduced to farmers in Benin in 2010 with the aim of reducing the use of pesticides, mainly insecticides, while increasing both yield and quality. Initially the EFNs were trialed on cabbage production first in Benin (Martin et al., 2006; Licciardi et al., 2008) then in Kenya as part of an IPM project funded through USAID and Cirad (www.bionetagro.com). In Benin the EFNs were allocated to participating farmers at no cost through a non-governmental organization (NGO). However, the free allocation of EFNs cannot be sustained after the trial phase so it is important to understand the characteristics of the nets farmers prefer, and the yield to cost ratio compared to pesticides.

The objectives of our study are (1) to assess smallholder farmers' preferences for characteristics of different pest control strategies, (2) to test if there is preference variation across farmers, and, if so, (3) to reveal the factors determining this variation, and (4) to compare the benefits and costs of EFNs with those associated with pesticides.

We do this by applying a choice experiment (CE), a multi-attribute non-market valuation technique. Because the EFNs are not yet on the market, the value of the nets cannot be observed from market transactions. However, non-market valuation techniques make it possible to predict farmers' preferences and values for the characteristics of EFNs and hence for the benefit of using EFNs as substitutes for insecticides. These benefits are measured through farmers' changes in welfare that come with the change from their current farming practice to the use of EFNs and are expressed as their willingness-to-pay (WTP). The welfare estimates can be used in a benefit-cost analysis and, by aggregating farmer's welfare estimates for each of the characteristics of the EFNs, we can make recommendations about the future price of the nets as well as the yield that needs to be achieved to make the EFNs economically viable. A few CEs have investigated preferences related to pesticide use by farmers (e.g. Christensen et al., 2011; Richardson et al., 2013) but only a few studies in SSA have looked at the socio-economic implications of decreasing pesticide use, and then mostly at the effects of pesticides on health (e.g. Ngowi et al., 2007; Williamson, 2005; Garming and Waibel, 2009; Atreya et al., 2013).

2. Materials and methods

2.1. Study area

The study was carried out in two geographical zones, differing in soil type, fertility and land use systems. The first zone spreads along the Benin offshore sand bar and comprised five districts: Cotonou, Abomey-Calavi, Ouidah, Comé and Grand-Popo (Fig. 1). In this zone trials of EFN use have been implemented by the National Agricultural Research Institute of Benin (INRAB) through the NGO APRETECTRA.[1] The second zone does not border the sea and comprises nine districts: Bopa, Houéyogbé, Lokossa, Athiémé, Dogbo, Aplahoué, Toviklin, Klouékanmè, Lalo. In this zone EFN trials were diffused by the Regional Council of Market Gardeners (CRM-MC: Conseil Régional des Maraîchers du Mono-Couffo). The fourteen districts are spread across four departments: Littoral (Cotonou), Atlantique (Abomey-Calavi and Ouidah de Comé), Mono (Comé, Grand-Popo, Bopa, Houéyogbé, Lokossa and Athiémé) and Couffo (Dogbo, Aplahoué, Toviklin, Klouékanmè, Lalo) (Fig. 1).

All respondents practice urban farming. Soils are poor and infertile in both zones. In the first zone the lack of suitable land for agriculture and the relatively high population density limits the land size for farmers to practice an intensive production system, which is suitable for exotic vegetables production (cabbage, eggplant, lettuce, watermelon, cucumber). Farmers in the second zone have more space and have low-input production systems. They also produce a range of exotic vegetables as well as local ones such as African eggplant 'gboma', pepper, amaranth and local spinach.

In the two research zones, as in the rest of Benin, the use of insecticides spray is almost ubiquitous and increasing because of growing insecticide resistance (Martin et al., 2005). Access to pesticides in the research area is further facilitated by government subsidies to purchase these products to boost production.

2.2. Sampling

In order to ensure efficient dissemination of knowledge about EFNs and how to use them, APRETECTRA and CRM-MC have created farmer networks. Each network consisted of six farmers: one farmer who actively took part in the EFN trials (from here on referred to as 'user') and five farmers who attended the trials during one cycle of vegetable production but who did not adopt the EFNs for their own vegetable production (from here on referred to as 'observers'). The list of these farmers was provided by APRETECTRA and CRM-MC, respectively. The reason we sampled only from these farmers is because, in order to adopt a new technology, farmers

[1] Association des Personnes Rénovatrices des Technologies Traditionnelles (Association for the renewing of traditional technologies).