Potentials of green consumerism for landrace conservation: evidence from eggplant production sector of India

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Abstract

The study examines the least-cost option of conserving landraces *in situ* by the development of market friction instruments, taking the case of eggplant production sector of India. The study uses the farm level data on production of hybrid and landrace eggplant and also relies on consumer preference data for fruit attributes. An examination of the cost and return structure of eggplant farming in the study area reveals that the incremental farm price of eggplant products of landrace origin eclipses the yield advantage of hybrids varieties. Box-Cox model, fitted for hedonic price estimation, indicates that along with the external fruit characteristics the landrace status is the main reason behind their higher farm price. We observe that there is potential for green markets in emerging economies such as India, even though the existing markets are highly informal and inadequate in catering to the needs of eco-friendly consumers. It is also observed that the increment in the farm price of eggplant landraces over hybrids is realized in the complete absence of formal market segmentation, that is, without any formal labelling or certification scheme. Further, the study examines the consumptive value of landrace attribute, using the consumer household data from urban India and the stated preference methods. Possibly due to the information asymmetries and other imperfections existing in this market, the price increment currently realized by the eggplant farmers is only a fraction of consumers' willingness to pay for landraces. The study concludes that, by employing friction instruments to eliminate the information asymmetries in the market, sustained on-farm use of landraces could be assured in an effective way.

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1. Introduction

There is an active debate surrounding the relationship between dissemination of high yielding modern varieties (MVs) and erosion of plant genetic diversity, as the former is often argued to have the potential to induce genetic uniformity rather than crop diversity. According to Shiva (1989), the improved cereal varieties during Green Revolution displaced the diversity of traditionally grown crops by inducing monocultures of varieties having narrow genetic base in India. The 'genetic erosion hypothesis' – that is, adoption of modern high yielding varieties eliminate the diversity of indigenous crop varieties, as proposed by Harlan (1975) – got significant support in literature (e.g. Fowler and Mooney, 1990; Berg et al., 1991; Pretty, 1995; FAO, 1996). Wood and Lenné (1997), however, raised a completely different perspective that the diffusion of new varieties could only be one of the multiple intervening factors behind loss of landraces. According to them, MVs are also capable of maintaining and facilitating the genetic diversity, rather than inevitably replacing the landraces. In a seminal paper on 'Green Revolution caused genetic erosion' in the case of bread wheat in India, Smale (1997) pointed out that, though a causal relationship between introduction of semi-dwarf varieties and genetic erosion cannot be established, replacement of traditional varieties by products of plant breeding programs began early 20th century. Our assumption in this paper is made simple keeping the aforementioned debate in view: the introduction of MVs would detrimentally impact the area under landrace cultivation as it is associated with an increase in farmers' opportunity cost to cultivate landraces. Direction of impact of this act of substitution on genetic diversity would depend on the chances of loss of genes from the crop species, which in turn would depend up on the nature of co-existence of MVs with landraces, rustification, pedigrees of improved varieties etc. (Wood and Lenné, 1997; Smale, 1997).

The present study examines a least-cost option for landrace conservation under the potential challenge from MV dissemination. In the locales where the local varieties are better adapted to the local agro-climatic conditions in comparison to the MVs, cultivating them would entail relatively lower per-unit cost (Smale et al., 2004). In the absence of such natural incentives of increased adaptability, market segmentation for landrace products is hypothesized to facilitate *de facto* conservation through enhanced private value of these varieties for the farming community. In addition, evolving consumer preferences coupled with economic growth is creating emergent conditions for an increased demand for eco-friendly products. In this juncture, our paper addresses the potential of market based instruments (MBI) in conserving the local varieties *in situ*. The case of eggplant crop in India is taken for illustration. This is one of the most important vegetable crops and is highly heterogeneous in India with respect to its varieties. More importantly, product differentiation can be made by fruit characteristics, viz. shape, colour, variegation and spines. In other words, fruit characteristics act as a good proxy for formal labelling schemes. This helps meet the diversified consumer demand, which in turn determines the market prices variation across different varieties of eggplant fruits.

The domestic market for eco-friendly (green) products in developing economies is still rather small due to slow moving consumer preferences and the limited responsiveness of producers and suppliers (Grote, 2002). Nevertheless, there can be a significant potential for green markets in emerging economies such as India, even though the existing markets are highly informal in catering the needs of eco-friendly consumers (Krishna and Qaim, 2008). In this regard it is necessary to develop conceptual models on market segmentation for landrace products at different levels of maturity in order to shed light on the potential of green consumerism as associated with landrace traits in emergent economies. The product heterogeneity in case of eggplant makes a case for the existence of differential markets which in turn can overcome the basic difficulty of imperfect information to some degree. We are examining the potentials of 'green consumerism' to help conserve local eggplant varieties *in situ* by transferring the price premium of such green products directly to farming communities.

Given the rapidly evolving seed markets in India, the eggplant production sector is also congenial for the analysis of the impacts of agricultural development policy strategies on *in situ* landrace conservation outcomes. It should be noted that the F_1 hybrids are being widely cultivated in southern India and in addition eggplant is also being genetically modified to express pest resistance in order to reduce pesticide dependence in crop production and ultimately enhance the farm profitability (Krishna and Qaim, 2007). While at the same time the biotech thrust in eggplant crops continues in India, consumer demand for indigenous and diverse vegetables can be thought of as a key factor defining such technology adoption and diffusion patterns, and in turn, their associated welfare impacts on farming communities. Keeping these issues in purview, this study presents and analyses primary data on production and consumption of eggplant to draw inference on the likely impacts of potentially emerging green markets (for eggplant products) on technology adoption and varietal diversity conservation.

The paper proceeds with a review of literature on the possible impacts of market development on conservation of plant genetic resources (PGRs). The rationale behind selecting eggplant production system in India is briefly described in section 3. Following section describes the case study, sampling procedure and data collection, while section 5 reports and discusses the empirical results based on the hedonic price models based on farm-gate prices, as well as on consumer preferences for eggplant attributes. The last section concludes and draws some policy implications.

2. Market development and PGR conservation

2.1. Market instruments for PGR conservation

There is an array of market based instruments that may be designed to incorporate the external cost of production or consumption activities, for instance, by pricing processes or products, or by creating property rights and facilitating the establishment of proxy markets associated to environmental services. In addition, market-friction instruments (MFIs) can be used to improve the operation of existing (imperfect) markets (Cutbush, 2006; Whitten *et al*., 2007). Amongst the MFIs, labelling and certification are being used to connect the demand and supply sides of the market and to establish an advantage for those who are in a position to help conserve biodiversity by labelling their products as such. The evolving global market for biodiversity-conserving ‘shade coffee’ is an example (CEC, 1999) and this is also the case with labelling proposals with regard to the potential introduction of genetically modified (GM) foods in India (Bansal, 2007).

MFIs work through exogenous economic factors that are pivotal in determining consumer preferences. For example, due to economic growth as disposable per capita income rises, consumer preferences for quality are increasingly expressed in various food markets (Zilberman and Lipper, 2005). Surveys in both developed and developing economies have found that consumers are willing to pay higher prices for ‘environment-friendlier’ products

(Shams, 1995; Florax *et al*., 2005; Krishna and Qaim, 2008). Nevertheless, there exists the challenge of translating the growing concern for the environment and related consumers' willingness to pay (WTP) into MFIs that would be conducive to *in situ* conservation of PGRs. Niche markets allowing for the emergence of green price premiums through certification and labelling are gaining relevance in this juncture (Basu *et al*., 2003). As an example, new marketing opportunities are being sought by the growing consumer awareness for 'organic' production processes and demand for specialty foods in developed economies (Grote, 2002; Garibay and Jyoti, 2003). In this context, the emerging question is whether using MFIs to help identify the traits of landraces/cultivars for important crops help the conservation of PGRs by farmers themselves, through price premium incentive mechanisms.

Much work has been done to shed light on valuing and identifying consumer preferences for agricultural products with specific attributes, such as the use of GM organisms in food production (e.g. Kontoleon and Yabe, 2006; Rigby and Burton, 2006), and the cultivation of landraces by farmers themselves (cf. Birol and Rayn-Villalba, *forthcoming*). However, there is still much to be learnt about consumer preferences and values assigned to landrace products by non-farmer food consumers in developing countries. Shedding light on this issue would help to better design and support incipient MFIs linked to local food markets that in turn may provide the right incentives to farmers for in-situ conservation of PGRs (Brush, 2000; 2004). Furthermore, while there are interesting studies on the management of on-farm crop diversity that addresses farmers' perceptions and choices regarding morphological traits (Birol *et al*., 2006; Birol and Rayn-Villalba, *forthcoming*), this literature tends to neglect the important role of non-farmer buyer preferences especially when food products linked to landraces are associated only with informal market chains.

This is the case in most developing countries, where product differentiation occurs without formal certification and labels. Instead, consumer knowledge about phenotypic characteristics of products along with trust on farmers/sellers may act as proxies for labelling. However, getting rid of market frictions is challenging due to the existing information asymmetry between farmers and consumers especially as regards the value of the landrace attribute of the food crop. In this juncture, informal markets can be seen as prematurely linking the demand and supply for such green products.

2.2. A conceptual framework of MFIs for landraces

The conservation of landraces during the diffusion process of improved (modern) varieties (MVs) is associated with a considerable opportunity cost, *OC*, to farmers, which is the difference between the gross margin per unit area of the MVs, denoted as GM^M, and landraces, GM^L. Assuming that variable costs of producing MVs and landraces are equal, then, $OC = Y^M P^M - Y^L P^L$, where $Y^M(Y^L)$ and P^M (P^L) denote the yield and the unit market price of MVs (landraces), respectively. In addition, assuming that $P^M=P^L$ and $Y^M \geq Y^L$, the opportunity cost of conserving landraces would be the value of the potential incremental yield of MVs. In other words, *ceteris paribus,* in the absence of a price premium of landraces (when farmers' utility does not depend on either cultivating MV or landraces) it is expected that profit maximizing farmers would switch production from landraces to MVs.

Given exogenous consumers' preferences, products derived from landraces may be associated with various attributes that are superior to MVs (e.g., taste, cooking quality etc.), thus having an additional direct use value to MVs. In addition, landrace products may have non-use values given some consumers' cultural attitudes towards conserving local crop varieties. Here, we illustrate this point to understand the possible impacts of market development for landraces when these compete with MVs for a share of total consumer demand for the crop. Following Van Dusen (2006), Figure 1 is adapted to depict the production possibility frontier (PPF) representing the efficient production mix between the higher yielding MVs and landraces by a representative farming community under the best available technology.

[*FIGURE 1 HERE*]

Farmers' decisions regarding the mix of MV and landrace cultivation are guided by many factors, including exogenous market price signals (Pascual and Perrings, 2007). In Figure 1, the slope of the price lines UV and WX equals the ratio of the price of landrace products to the price of products of MVs. In this starting case, we assume that no price differentiation can be made when consumers cannot differentiate MVs from landrace derived products in the market stalls, i.e., $P^{L0} = P^{M}$ with L_0 indicating the starting price of the landrace product; the 45° price line UV has a slope of minus one. When both landrace and MVs products are undistinguishable in appearance and are unlabeled, consumers are not able to recognize landrace products from MVs in the market. In this simple case, and unless the landraces respond differently to the local agro-climatic conditions and turn more productive than MVs, optimality is associated with the corner solution, (0, Q^{M0}), where production is entirely allocated to MVs. This is a simple and expected story, similar to the interaction between dominant and recessive genes in genetics. In the simple case depicted above the MV is the 'dominant' crop and the landrace is the 'recessive' crop; the market thus favours the dominant one by the decentralized decision of individual, private maximizing, farmers.

But when farmers also consume their own produce and their utility levels depend on whether the consumption derives from landraces or MVs, the simple genetics complicates. Rather than market prices, shadow prices need to be estimated and any model needs to take into account that production and consumption decisions become endogenous by the farmers. Thus, even if $P^{L0} = P^{M}$, the outcome would be associated with a residual level of production of landraces in order to meet farm households' tastes for landraces. However, given that the focus is upon the entire market demand in which non-farm consumers make up almost all of it, farmers' marginal consumption level is neglected in the analysis.

Notwithstanding this simplification, it should be noted that even when the market segmentation between MVs and landraces is imperfect (due to non-existing formal labelling schemes), a share of the total of non-farmer consumers are often able to recognize the landrace produce as it is usually the case that certain product attributes can be revealed, though not perfectly, through for instance, external appearance of the product. This revelation in turn may depend, for instance, on consumers' experience through repeated purchases of such products or through the proximity to the cultivation centres. This consumer information would make the realized demand of landrace products to increase, and, given a static supply, would make the price of landraces to increase from P^{M} to P^{L1}. The new price line becomes WX with slope $-P^{L1}/P^{M}$. When the possibility of revealing certain proxies for the superiority of a given landrace attribute exists, the farming community would shift the optimal production mix to level (Q^{M1}, Q^{L1}), corresponding to the new point of tangency between the price line WX and the PPF.

However, not all consumer households may be able to identify completely the landrace products from MVs. Hence, consumers' imperfect information prevents the market from allocating MVs and landraces in a way that is socially optimal. This information gap leads to typical market information problems in the form of adverse selection and moral hazard, originally described by Akerlof (1970). In this pervasive situation, MVs would be over-represented to the detriment of landraces. The socially optimal production mix would correspond to the point of tangency between the consumer community's virtual price curve YZ and the PPF. It is noteworthy that a price curve arises as the shadow price for landraces, P^{L2}, is associated with the marginal utility of consumption of society, which in turn changes depending on the level of landraces already demanded. The new shadow price is higher than the price farmers obtain under existing imperfect information levels, i.e. $P^{L2} > P^{L1} > P^{L0}$. This situation can be readdressed by the use of MFIs such as labels and certification schemes allowing consumer information to be translated into a price premium for landrace products. This in turn would be translated to a higher demand for landraces which would need to be met by famers by further cultivating landraces if these are paid a price premium (at Q^{L2}). At the same time, this would curtail the diffusion of MVs falling from Q^{M0} to Q^{M2}. It should be noted, though, that the level (Q^{L2}, Q^{M2}) is determined by consumers' attitude towards development and landrace cultivation. This is depicted by the possibility that the indifference curve YZ shifts downwards as society moves away from its 'productivity perspective' towards a more 'conservative perspective' (Heisey *et al.*, 1997; Pascual and Perrings, 2007).

3. Landrace conservation and emergence of MVs in the eggplant production sector of India

India has made significant progress in recent years towards setting up a legal regime for the management of its PGRs (Biber-Klemm *et al.*, 2005).[1] However, agricultural development

[1] In the recent past, India has made significant progress in setting up a legal regime for the management of PGRs, in three separate legislative instruments: (i) the Protection of Plant Varieties

policies are increasingly focused on development and dissemination of high yielding MVs with limited genetic diversity (Krishna and Qaim, 2007). This situation exemplifies the agricultural development versus PGR conservation political dichotomy or clash of interests, which is explicit in the case of eggplant crop in India.

India is the second largest producer of eggplant in the world (FAOSTAT, 2006). Production is dominated by small-scale and marginal farmers, and hence the crop is often described as the “poor man’s vegetable”. Traditionally eggplant farmers have maintained and supplied the crop seeds, resulting in special varieties adapted to the region’s environment as well as local consumers’ tastes. The three most common cultivated eggplant varieties in India are *Solanum melongena* var. *esculentum* (round/egg-shaped fruits), *S. m* var. *serpentinum* (long, slender fruits) and *S. m* var. *depressum* (dwarf plants) (Bose *et al*., 2002). Further, in addition as food crop, a number of wild relatives of eggplant are identified in indigenous medicine systems as having medicinal properties (Daunay *et al*., 2000). Also, eggplant landraces and their wild relatives have been documented as being valuable due to their resistance against pests and diseases (Sridhar *et al.*, 2001). Additionally, some landraces have non-use values. For example, the *Matti Gulla* variety of eggplant grown in villages of Karnataka is believed to be ‘divine’.

Notwithstanding the array of different values associated with eggplant landraces, we focus on the narrower, but significant, consumptive value of eggplant varietal diversity. Given its high diversity, it is not surprising to find that consumer preference for eggplant fruits are expressed according to characteristics such as taste, colour, size, spiny-calyx, shape etc. Such preferences become complex to analyze due to the large combination of the fruit’s characteristics that in turn has historically led to the cultivation of eggplant varieties with very diverse phenotypes.[2] In the face of such diversity, there has also been a significant adoption of eggplant MVs in the country (Krishna and Qaim, 2007). Since the 1980s, an

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and Farmers’ Rights Act, (ii) the Biodiversity Bill, and (iii) the Patents (Amendment) Act of 2002. The separation of various elements into three legislations is partly due to India’s international legal obligations, viz. the Trade related aspects of Intellectual Property Rights (TRIPs) Agreement and the Convention on Biological Diversity (CBD).

[2] Due to the limitations of existing literature on eggplant production and marketing in India, these observations are made from an expert survey among the scientists of Indian Horticultural Research Institute (Bangalore) and Indian Institute of Vegetable Research (Varanasi) as well as District Horticultural Officers of Karnataka and Andhra Pradesh.

increasing number of the F_1 eggplant hybrid varieties bred by private seed companies are being commercialized. More specifically, hybrids are being widely cultivated in the southern states of Karnataka, Andhra Pradesh, and Maharashtra. By contrast, in eastern parts of India (especially West Bengal and Orissa states, which together account for around 50% of the total eggplant area in the country), the adoption of hybrid seeds is marginal as the landraces are more adapted to the local soil and climatic conditions (Krishna and Qaim, 2007).

The MV adopting states were highly diverse in terms of eggplant landrace varieties before the massive introduction of hybrid seeds two decades ago. Since then, a gradual shift by farmers from cultivating landraces to hybrids has been observed due to policy interventions that facilitate increased private investment in the seed industry and state government incentives directly influencing farmers' decision to cultivate MVs. For example, the government of Andhra Pradesh provides subsidies to vegetable farmers to adopt hybrids seed in order to increase productivity (Rao, 2006). The resulting productivity increase due to MV adoption has been noticeable. For instance, average yield of eggplant in Karnataka, where hybrids are widely adopted, is 58% higher compared to West Bengal, where adoption of such MVs is marginal (Krishna and Qaim, 2007).

Apart from the conventional breeding sector, modern biotechnology poses new challenges to on-farm varietal conservation. Recognizing the economic relevance of resistant breeds, GM eggplant hybrids and open pollinated varieties are currently developed under unique public-private sector research collaboration in India (Krishna and Qaim, 2007). Adoption of high yielding varieties like GM eggplant is often perceived both to foster agricultural development and to undermine the diversity in PGRs. Critics call attention to the displacement of genetic diversity and transgenic escape (due to natural out-crossing) as amongst the potential environmental threats associated with GM crops (Ervin *et al*., 2001; Greenpeace India, 2006).[3] In this context, the Task Force on Application of Biotechnology, set up by the Indian Ministry of Agriculture to develop a national

[3] It should be noted that while selective breeding generated 'green revolution' type seed varieties by introducing distinct genetic material from those of traditional varieties, biotechnology alters existing seed varieties modifying a few genes. It has been pointed out that the extent of loss in agrobiodiversity due to the introduction of transgenics depends on the degree in which local transgenics are adopted rather than on a single generic GM variety (Zilberman *et al*., 2004).

framework for biosafety, has recommended that the critical areas with respect agri-biodiversity should be protected and earmarked as ‘agro-biodiversity sanctuaries’, where the cultivation of GM crops should be prohibited (GoI, 2004). In the face of such government rhetoric, the drivers of GM technology adoption are complex. Besides being critically determined by public attitude towards such technology (Nielsen *et al*., 2003; Zilberman and Lipper, 2005), it also depends on the extent to which public policy moulds under the pressures from pro- and anti-GM organizations, and on the extend of farmers’ attitude towards experimentation with GM crops as recently pointed out by Gupta and Chandak (2005). Regarding the consumers’ broad attitudes towards introduction of GM foods, there are some recent studies that have attempted to predict these for the Indian consumers and have indicated a general positive attitude (Krishna and Qaim, 2008; Anand *et al*., 2007). However, the evidence is not fully settled as the responses of consumers to attitude surveys are under hypothetical conditions, which can be slightly or highly removed from the revealed preference through their purchasing behaviour. In addition, Bansal (2007) observes that the importance of labelling and consumer preferences varies with social groups. Further, with a rather limited awareness on GM foods by the general public, media exposure and formal education has been seen to reduce the acceptance by consumers of GM foods (Krishna and Qaim, 2008). There is a possibility that once the GM eggplant comes to be marketed in India, the consumers’ knowledge and perception, which need not be objective or scientific, may alter significantly. The present study gains significance in this juncture, by providing an insight into the potential welfare changes due to consumer aversion towards a production technology. The conventional hybrids and GM varieties are expected to have a positive impact on farm productivity even though they may be less favoured from the consumers’ perspective.

4. The case study

We use primary data from eggplant producers and consumers in India. The study combines the revealed preference of society for landrace products using data on farm price realized by eggplant cultivators and stated preference from consumers’ perspective. Data on eggplant cultivation were collected from a cross section of 240 farm households in 2005 from Andhra Pradesh and Karnataka, two leading eggplant producing states in South India. The survey covered the major eggplant-growing tracts within the selected states, most of which are located in the river belts – Krishna in Andhra Pradesh, and Cauveri in Karnataka. Using a stratified random sample, six districts and 13 *taluks* (revenue subdivisions within each district) were selected purposively based on the area under eggplant cultivation. Villages and farm households were selected randomly. 36 percent of the sampled households cultivate eggplant landraces, implying an adoption rate of MV technology of 64 percent in the study area.

Farm economic data was gathered from these households, including yields, variable production costs and farm prices obtained for eggplant fruits. In addition, information about the attributes of the marketed eggplant fruits were gathered from each farmer, including the skin colour, size, percentage of borer infestation in the marketed eggplant lot and presence of spines of fruit calyx. Such information is complemented with data on socio-economic characteristics of the farm household through structured surveys. Due to their close proximity to the perennial rivers, eggplant farmers of survey do not face major problems of water shortage. Often, farms even have more than one source of irrigation. The average land holding of the sampled farms is 4.96 acres, and the mean per capita household income is estimated to be around 20 thousand rupees (US$ 500). The respondents received limited formal education, with the average being less than 5 years of schooling. This sampling framework does not include households that grow only a few vegetable plants in their kitchen gardens for own-consumption.

In addition, data from vegetable consumers was also collected in 2006 from five important urban locations in India: New Delhi, Bangalore, Kolkata, Kolar, and Barddhaman. The first three are among the largest cities of India and administrated by municipal corporations, whereas Kolar and Barddhaman are two district headquarters in the states Karnataka and West Bengal respectively, and are in close proximity to important eggplant production regions.

The information about consumers in each of these urban areas also corresponds to a stratified random sample design and corporation wards and consumer households were selected randomly from each of these urban areas. In total, the sample of consumers makes up 629 individuals (each from a different household) from 61 corporation wards. In comparison to the sample of the farm survey, the consumer respondents show higher levels of education and income, with an average of about 10 years of formal schooling and about

Rs. 30 thousand (US$ 747) as per capita income. The survey was designed to gather information about consumers' preferences and attitudes towards different eggplant characteristics, including those of landrace fruits. In a second stage, for those individuals who indicated a clear preference for landraces over hybrids, a dichotomous choice question on their willingness to purchase landrace products was posed against hypothetical price increments, in order to estimate the consumptive (use-) value of eggplant landraces.[4]

5. Eggplant landrace production, pricing and consumption attitudes in South India

5.1. Productivity analysis

Table 1 provides information about yields, total and per-unit cost and return structure of eggplant (landrace vs. hybrid) cultivation in South India. Eggplant hybrids show a marked superiority over landraces with respect to yield. The average marketed yield is 95 versus 122 quintals (Q) per acre for landraces and hybrids, respectively.[5] It should also be noted that the marketable yield is not very different in both cases as farm households' consumption of eggplant is negligible. The per-unit cost of hybrid cultivation is about 29% lower (albeit statistically insignificant) in comparison with landraces. On the other hand, the farm price obtained for landraces (Rs.501/Q) is around 31% higher in comparison with the hybrid products (Rs. 383/Q).

[*TABLE 1 HERE*]

[*TABLE 2 HERE*]

As one would have expected, due to similar cropping techniques, there is no significant difference regarding the total variable and per-unit cost of cultivation of landraces versus hybrids. However, the cost structure varies between the two as shown in Table 2. The main difference is that in the study area, landraces are mostly cultivated in leased-in land and the associated rent raises the total cost. Labour cost is also higher for landrace cultivation,

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4 Detailed information about farmer and consumer households are available from Krishna and Qaim (2007; 2008), respectively.

5 In India, the quintal is equivalent to 100 kg, and is a standard measurement of mass for agricultural products.

mainly because hybrid adoption and seedling purchase – the practice that eliminates the labour expenses associated with nursery raising – are often found associated in the study area. In the case of hybrid production, however, the cost of material inputs (viz. as seeds, fungicides, manures, and fertilizers) is higher. The hybrid seeds, generally, are found highly responsive to the chemical inputs, which may be partly attributing to this difference. On the other hand, the farm and household characteristics which enhance the adoption of hybrid seeds could be responsible for higher use of purchased inputs. As can also be seen from Table 1, landrace eggplants are associated with a significant higher price of about 30%. This partly circumvents its productivity disadvantage with respect to the hybrid varieties. In fact, the higher price earned by landraces is responsible for the similar economic performance of hybrids and landraces. The question is whether the price differential is due to the supply structure of hybrids in the incompletely segmented market, or whether it also has to do with the way consumers perceive the product attributes and thus there may be a demand component too. This is akin to the hypothesis that consumers have attitudes and preferences that favour landrace attributes.

5.2. Price analysis

According to Lancaster's (1966) theory of the demand for 'characteristics' or intrinsic quality features, consumption is an activity in which goods and services, singly or in combination, are inputs and in which the output is a collection of characteristics. This theory lays the framework of the hedonic pricing method used to examine the price structure of different agricultural products (e.g., Unnevehr, 1986; Dalton, 2004; Edmeades, 2007; Huang and Lin, 2007). Here we follow this tradition to assess the effects of both product attributes and farmer characteristics in determining the market price of eggplant fruits in Southeast India.

The farm price of eggplant fruits is hypothesized as a function of fruit, regional, seasonal, farm and household characteristics. We adopt a linear Box-Cox transformation of the of the hedonic price function, after testing the significance of model selection over alternatives through likelihood ratio tests. The linear Box-Cox transformation requires the dependent variable $DEP(\theta)$ to be scaled by a factor θ, such that:

$$DEP(\theta) = \frac{DEP^{\theta} - 1}{\theta}$$ (Cropper *et al*., 1988).

The dependent variable for hedonic function is eggplant price (Rs/Q) obtained by the farmers of the study area. The model turns out to be linear when $\theta = 1$, inverse if $\theta = -1$, and semi-log when $\theta = 0$. Using our data, the likelihood ratio test statistics rejects the null hypotheses of θ =1, θ =-1, and θ =1, implying that linear, inverse and semi-log specifications would not be appropriate. The marginal implicit prices (MIP) are calculated as *c*(*x*/þ), where *c* is the estimated coefficient, and *x* and þ are the mean values of the explanatory and dependent variables.

The estimation of the hedonic model was carried out employing the Box-Cox models in two steps. First, the model [I] is estimated just with the product and farming attributes as explanatory variables. Model [II] was estimated, which differs from [I] by the addition of five household characteristics. If the product attributes (like hybrid status) were endogenously determined by the farm household characteristics, they might cause a simultaneity problem, and correlation between explanatory variables and the error term would render the estimates inconsistent. However, the likelihood ratio test suggests that model [II] fits the data better than the previous one (at 0.05 level), and the superior model only is shown in Table 3.

[*TABLE 3 HERE*]

From the analysis it can be seen that hybrid eggplants are associated, a marginal implicit farm price of minus Rs. 86/Q in comparison to landraces. It is already observed that the average absolute price difference between landrace and hybrid products is Rs.118/Q (cf. Table 1). This difference could be due to the product characteristics of landraces that are not common in hybrid eggplants, or due landrace status itself. Farmer characteristics that determine his/her bargaining power while selling the product is also hypothesised to have impact on farm price. By incorporating fruit and household characteristics together in the model, the hedonic function indicates that 73% of the aforementioned farm price gap is due to the landrace attribute, whereas the 27% (Rs.32/Q) is attributed to the fruit characteristics that are not common in hybrids and farmer characteristics. In case of other fruit characteristics, one can see that the purple fruits are cheaper in the market by Rs.82/Q compared to the green/white skinned ones. Hybrids and landraces of eggplant are available in both colours, showing that the green-landraces would be highly expensive for the vegetable consumers in comparison to purple fruits of hybrids. In addition, the presence of spines in the fruit calyx is found to enhance the farm price by Rs.241/Q. Though certain hybrids are possessed with spiny calyx, consumers commonly associate this attribute with landrace status.[6] Hence, adverse selection due to this information asymmetry might be one of the reasons for the associated high marginal implicit price of spiny calyx.

There are other important variables that should also be considered. For instance, there exists significant seasonal variation in eggplant prices. The data show that the per-quintal farm price during *Kharif* season (that starts with the on-set of southwest monsoon in July, and ends with it on October) is Rs.133 and Rs.398 higher in comparison to the *Rabi* (winter) and summer seasons, respectively. Another important variable is the effective distance to market, as indicated by the time taken to transport the produce to the market place. It appears that the longer the time that is needed during transportation, the lower the final price is, reflecting the effect on the freshness of fruits.

The model also shows that when looking at farmers' characteristics, experience in eggplant farming is positively determining the farm price, with a marginal effect of Rs.3/Q per year of experience. It can thus be hypothesized that additional farming experience may provide better information about the complex eggplant market and its price structure and this effect may influence the bargaining power. Similar effects on bargaining power were observed by Harding *et al*. (2003) in a different context. Lastly, as it would be expected through economics of scale, the farm size owned by the farmer is associated with a negative MIP, with a unit increase in acreage reducing the market price by Rs.3/Q.

These results indicate that the landrace attribute *per se* provides a significantly higher price for the cultivators, and that the market is differentiated to certain degree for catering the needs of consumers. Having said this, information asymmetries and market imperfections are present. Due to numerous middle-men in Indian vegetable markets, consumer prices are

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[6] Source: primary data collection among the consumer households.

actually much higher than the farm prices (Gandhi and Namboodiri, 2004). Such transaction costs might be playing a crucial role in the transmission of the value consumers attach with the landrace trait to the cultivator. In the complete absence of labels, transaction costs in keeping the eggplant market segmented for landraces rises with the number of market agents. This creates a drift in the supply function and thus transfers only a fraction of consumers' WTP to the hands of farmers. In addition, there are also consumers who are not able to differentiate the products, i.e., landraces vs. hybrids, as no formal labelling scheme exists indicating this important characteristic of the produce. The situation is similar to that represented by point Q^1 in Figure 1. This would imply that albeit the associated price for eggplant landraces is higher, this may not be linked to consumer demand to a full extent. As explained earlier, the optimal mix of cultivation of landraces versus modern hybrid varieties, as denoted by point Q^2 in Figure 1, can be found only by knowing consumers' preferences, that is, by directly obtaining the willingness to pay estimate that consumers attach to the landrace attribute. This next step is explained next based on a consumer survey carried out in urban India.

5.3. Analysis of consumer preferences

The majority of surveyed consumers (79 per cent) stated that landrace products are distinguishable from the hybrid ones in the eggplant market. Their preference for the eggplant type – hybrids or landraces – is elicited for the case where there is no price difference between them. While on average 75% of all sampled consumers preferred products of landrace eggplant, only 13% showed a preference for hybrids, the rest being indifferent between landrace and hybrid eggplants (Table 4). It is also observed that the preference for landraces is high in Kolkata and Barddhaman, the cities is surrounded by landrace growing tracts. Similar reasoning can be traced out for the comparatively high preference for hybrid eggplant (around 20% among respondents) in New Delhi and Bangalore, as these cities are located far from the production locations or surrounded by hybrid eggplant growing tracts.

[*TABLE 4 HERE*]

In order to shed light on consumers' strict preference of eggplant landrace products over hybrids, a probit model is estimated (Table 5). The data suggest that older individuals show a more positive attitude towards landrace eggplants, which is unsurprising as the habit of consumption is a major factor behind preferences. Additionally, the proxies of information availability, viz. education and consumers' skills to distinguish landrace products in the market, appear to be important. The landrace preference is controlled for the actual price of the currently purchasing eggplant product. Consumers were paying Rs.10.49/kg of eggplant on average in the retail market, which is 2.49 times higher the selling price obtained by the farmers in the survey. There is significant inter-household variation in the retail price of eggplant, which mainly depends on the source from which the households purchase the vegetables. The current retail market price has a significant effect on the likelihood of purchasing landraces over hybrid fruits, while the household disposable income appears not to impact. That is, higher the market price of the eggplant fruit currently paid by the consumer, the lower would be likelihood to select landraces, as these are already associated of being more expensive. It is also interesting to show that those consumers from smaller towns are more inclined towards landrace consumption.

[*TABLE 5 HERE*]

From the above evidence, it appears that there are a sizeable proportion of urban consumers who perceive eggplant landraces as having some superior characteristics when compared with hybrids. This suggests that in principle it should be possible to assess the strength of such perceptions and preferences through a monetary metric. By doing so, we could shed light on understanding which of these attributes could actually induce some kind of market segmentation for the landrace product in order to create a new market that could be conducive to reward farmers for conserving such agrobiodiversity *in situ*. We attempt to do so by employing a stated preference model on consumers' willingness to pay (WTP) for the landrace attribute of the eggplants that they purchase in the food markets in the urban regions of New Delhi, Bangalore, Kolar, Kolkata and Barddhaman.

Urban consumer's WTP for landrace eggplants (P^*) is estimated using a random utility framework (Bateman *et al*. 2002). Consumers preferring landrace varieties at the market price are asked whether they would be willing to purchase it at a higher price (P^H). The bid structure utilized in the study is derived based upon smaller scale pilot survey and the price increments are then varied randomly across all surveyed consumers from 0.5 to eight rupees per kilo in equal intervals of Re. 0.5. Accordingly, there are four possible response groups: (G1) those consumers who prefer hybrid fruits at the existing market price, i.e., $P^* < 0$; (G2) those who are indifferent among landraces and hybrids at market price, i.e., $P^* = 0$; (G3) those who prefer landraces at the market price but are not willing to pay a price premium for the product, i.e., $0 \leq P^* < P^H$; and (G4) those who are willing to pay a price premium above the market price in order to be able to consume the landrace product, i.e., $P^* \geq P^H$ In order to estimate these price premiums, we apply an interval-censored model using maximum likelihood techniques (Cameron, 1988). The [lower, upper] limits of the interval, provided as the dependent variable in the model, are [$-\infty$, 0] for (G1), [0,0] for (G2), [0, P^H] for (G3), and [P^H, $+\infty$] for (G4). It is assumed that WTP is influenced by a vector of explanatory variables x. Hence, WTP = $\beta x + \varepsilon$, where β is a vector of coefficients, and ε is a normally distributed random error with mean zero and variance σ^2. The estimated coefficients can be directly interpreted as the marginal effects of the explanatory variables.

The estimation results of the WTP model appear in the right column of table 5. Since the dependent variable is measured as the price premium over the current market price of eggplant and there exists a wide variation in the price across the surveyed households, the model also includes the information of such market prices as an additional explanatory variable, which not surprisingly, shows a negative association with the stated WTP for the price premium elicited to the sampled individuals. According to the model, if the current retail market price increases by one rupee per kilo of the eggplant, the WTP premium for landrace attribute would decline by Re. 0.12/kg.

The personal characteristics of respondents, except income and education, are found to have no statistically significant effect upon consumers' stated WTP value. For instance, while age significantly contributes to forming the consumer preference towards landrace eggplants as shown in the probit model, becomes not significant in determining the WTP value. By contrast, consumer households' annual per capita income, which proxies their ability to pay, is found to raise the demand for the landrace attribute though at a declining rate; a Rs 1000 increase in per capita income would be associated with a price premium of

Rs.2.93/kg (which is equivalent to 28 percent of the current average retail market price) and indicates that economic growth and higher income levels may help consumers to accept a higher price premium in the eggplant market. This result confirms other similar ones found valuation studies on organic products (e.g., Florax *et al*., 2005). Lastly, formal education is also found to have a positive effect, with an additional year of schooling indicating an increase of the stated WTP for the price premium of Re. 0.13/kg.

Availability of information can foster the development of green markets significantly as in the case of labelled eco-products in developed countries (IFAV, 2001). In the Indian eggplant case, we find that consumers' ability to differentiate landrace products from that of hybrids is associated positively with their WTP, i.e., those consumers being more able to differentiate the landrace eggplants from the hybrid ones are WTP in the order of Rs.1.96/kg (19 percent of the retail market price). This positive association between information and consumers' WTP indicates that future market development for landraces can be fostered, if unbiased information is provided through labelling and certification.

Figure 2 shows the distribution of the estimated consumer WTP values. Using the results from Table 5, the mean WTP for landrace eggplant fruits amongst the urban consumers in India is estimated as a price premium of Rs. 3.87/kg in comparison to their hybrid counterpart. The median, Rs. 3.82/kg, is close to the mean value, indicating that the WTP distribution is relatively symmetric.

[*FIGURE 2 HERE*]

These values imply that the average price premium that consumers would be willing to pay for the landrace attribute is as much as 37% of the hybrid vegetable price. It also shows that at first sight the price premium farmers currently obtain (31%; cf. Table 1) is comparable with the consumers' WTP in percentage terms. However, in absolute terms there is a wide gap between the market price premium that farmers obtain for landrace products and the consumers' WTP for such premium. The price increment currently available for farmers is just Rs.1.18/kg, whereas consumers are willing to pay up to Rs.3.87/kg, i.e., the potential consumer premium is three times greater than the price premium currently realized by farmers. The difference between actual price margin obtained for the landrace cultivators and WTP stated by the consumer households could be explained as the difference existing between production situations Q^1 and Q^2 in Figure 1. The price associated with Q^2 , i.e., where the consumer's WTP is fully accounted for by the market, would be higher than that at Q^1, i.e., the current situation faced by farmers with incomplete information by consumers.

The above results indicate that the evolution of reliable marketing channels facilitating the distribution and a formal labelling system for landrace products could help bridge this gap. Shames (1995) indicated that the consumers in developing countries could abreast environment-friendlier products as they grow more aware about the environmental risks posed by rapid economic development. However, in the case study presented in this paper, the empirical evidence shows that the significant use value of landraces for vegetable consumers can be seen as a potentially major determinant for helping on-farm conservation in farmers' fields (if such premium were transferred to farmers to cultivate landraces) even with environmentalism still yet to surface in major Indian urban zones.

6. Conclusions

This study has explored the potentials of market development for *in situ* conservation of indigenous vegetable crop varieties and as a means to ensure the optimal co-existence of landraces and modern varieties. We have addressed the supply as well as demand sides of landrace trait, taking the case of eggplant in India. It should be stated that the introduction of MV eggplants into food production has been realized with only a partial success, as the perception about the quality of the crop produce is inferior from the consumers' perspective. This is an important reason why landrace eggplant still are marketed in urban India.

Along with the increase in consumers' awareness about the environmental externalities of intensive crop production, there has been a timid rise in the demand for green products in India (Parrott and Marsden, 2002; Anand, 2007). However, the potential to fully exploit niche markets for green products has often been considered as limited to wealthy nations, and rather small due to limited responsiveness of producers and suppliers in developing countries (Grote, 2002; Basu *et al*., 2003; Shushmul, 2005). But against this widespread opinion, the present study reports a potential demand for landrace products in new emergent economies, such as India, even though the current food market is not yet responding in order to meet the needs and preferences of eco-friendly consumers. Without a formal labelling system, the market still relies on trust towards vegetable farmers and sellers and knowing about fruit characteristics depicting landrace status. Such informal eco-labelling is clearly inefficient and this study shows that under relatively low transaction costs, markets for landraces could potentially emerge.

An examination of the supply and demand of eggplant in the country indicates the existence of an informal market segmentation for landraces, which helps farmers attain a higher price premium for growing landraces, at least as regards eggplants. Although hybrid eggplants are performing better in terms of yield, the market price is higher for landraces (about one third greater as compared with products from hybrid eggplants). Such price advantage of landraces eclipses to a large extent the yield advantage of hybrids. Four groups of reasons can be cited as price-determining for eggplant fruits: (i) the quality of landrace origin (consumers consider the landrace eggplant is having medicinal properties, for example), (ii) the fruit characteristics (like size, colour, spiny calyx etc) which are preferred by the consumers and commonly found associated with the landrace products, (iii) regional and seasonal factors, and (iv) the farmer characteristics as the sale is often associated with a bargain between farmer and buyer in the market place. The hedonic price model employed suggests that the landrace status alone explains around 70% of the farm price gap between landrace and hybrid products. Other fruit characteristics (like fruit colour), seasonal and farmer characteristics were also found significant in determining the market price. Although the market is differentiated to a certain degree for catering the diversified needs of consumers, information asymmetries still prevails in the system as the fruit attributes only inadequately substitute for labels and certificates. Hence, a contingent valuation model is estimated in order to elicit the total economic value of the landrace attribute from the perspective of the eggplant consumers in urban areas of India.

The results from the state preference model suggest that when the consumer WTP for the landrace attribute is compared with the farm price incentive, the price farmers obtain currently for landrace trait is just a small fraction of the value consumers attach to this same characteristic. The results from the WTP model also suggest that socio-economic variables along with the current market price significantly impact the potential niche market development for landrace products. Additionally, better quality information, for instance through signalling and labelling of products, is found to increase consumers' WTP further.

Of course, the optimal co-existence of landraces and modern varieties can only be assured if consumers' preferences through adequate pricing are transferred to farmers through a price incentive to grow landraces instead of modern varieties. The policy implication is quite straightforward. By developing practical schemes such as compulsory or voluntary labelling and certification to enhance information by consumers about the landrace attributes of vegetables and by setting appropriate low cost marketing channels to transfer part of the price premium back to farmers could help farmers to sustain the adoption of landraces against modern varieties. This is just one way to help conserve *in situ* agrobiodiversity in rural India with regard to crop varieties.

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Table 1. Economics of Eggplant Cultivation in south India

	Mean (Std. deviation)		Difference of hybrids over landraces (%)
	Landraces [N = 86]	Hybrids [N = 154]	
Variable cost (thousand Rs/acre)	18.98	17.29	-9.77
	(12.43)	(7.38)	
Yield (Q/acre)+	95.28	111.99	14.92*
	(58.33)	(78.21)	
Per unit cost of production (Rs/Q)	199.13	154.44	-28.94
	(330.81)	(125.12)	
Market price (Rs/Q)	501.25	383.47	-30.71***
	(151.03)	(147.39)	
Gross revenue (thousand Rs/acre)	47.76	42.94	-11.22
	(32.59)	(33.39)	
Net revenue (thousand Rs/acre)	28.79	25.65	-12.24
	(33.94)	(31.75)	

*, ***: Significant at 0.10 and 0.01 levels, respectively.
+ Quintal (Q) is equivalent to 100kg.

Table 2. Cost structure of eggplant cultivation in south India

	Mean (Std deviation)		Difference in mean (Std deviation)
	Hybrids	Landraces	
Variable costs (Rs/acre) on			
a) Planting material	1348.91	166.02	1182.89***
	(1323.73)	(649.74)	(152.13)
b) Manures	2002.01	1217.35	784.66***
	(2157.05)	(1721.99)	(270.91)
c) Chemical fertilizers	3944.63	2929.62	1015.01***
	(1936.66)	(1582.09)	(244.75)
d) Fungicides	270.39	163.85	106.53**
	(399.66)	(282.55)	(48.76)
e) Insecticides	2010.53	1897.63	112.90
	(2072.31)	(2012.64)	(276.11)
f) Hired human labour	6017.83	7071.38	-1053.55**
	(3827.85)	(6168.68)	(645.72)
g) Machine and animal labour	520.13	943.40	-423.27***
	(603.52)	(884.17)	(96.45)
h) Other costs	1180.55	4586.28	-3405.73***
	(2452.58)	(7039.02)	(625.09)
Total variable cost (Rs/acre)	17294.98	18975.53	-1680.55*
	(7380.94)	(12425.78)	(1278.25)

***, **,*: Statistically significant at 0.10, 0.05 and 0.01 per cent respectively (one tail t-test).

Table 3. Results of the Hedonic Price Estimation: Box-Cox Regression

	Coefficient (chi^2)	MIP
Intercept	11.733	
Dummy for hybrid eggplant	-0.452** (4.211)	-85.80
Share of borer infested fruits in the marketed lot (%)	0.021 (0.359)	
Dummy for purple fruits	-0.439** (4.666)	-81.93
Dummy for small or medium fruits	0.046 (0.043)	
Dummy for spiny calyx	0.580*** (9.175)	241.45
Dummy for Rabi season of cultivation	-0.502*** (8.585)	-132.83
Dummy for Summer season of cultivation	-0.820*** (14.041)	-397.73
Dummy for Andhra Pradesh	0.364 (1.360)	
Time taken to transport the produce to market (hours)	-0.150* (3.042)	-7.51
Experience of farmer in eggplant cultivation (years)	0.173*** (6.774)	3.20
Years of schooling obtained by farmer	0.008 (0.089)	
Dummy for mass media exposure	0.305* (2.925)	136.47
Size of farm owned by the household (acres)	-0.085* (2.815)	-3.11
Θ	0.195* (0.114)	
Log likelihood	-1514.92	
LR Chi^2 (13)	64.74	
Prob. > Chi^2	0.00	

MIP: Marginal Implicit Price.

*, **, *** : Statistically significant at 0.10, 0.05 and 0.01 per cent respectively

Table 4. Consumer preferences for hybrid vs. landrace eggplants in urban India in 2006

Preference	Number of households in					
	New Delhi	Bangalore	Kolar	Kolkata	Barddhaman	Total
Hybrids	34	29	11	7	0	81
(%)	(22.08)	(18.95)	(13.92)	(4.27)	(0.00)	(12.88)
Indifferent	24	19	7	18	18	86
(%)	(15.58)	(12.42)	(8.86)	(10.98)	(22.78)	(13.67)
Landraces	96	105	61	139	61	462
(%)	(62.34)	(68.63)	(77.22)	(84.76)	(77.22)	(73.45)
Total	154	153	79	164	79	629
(%)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)	(100.00)

Table 5. Factors contributing to consumer preference and WTP for landrace eggplant fruits

Variable	Probit Model: Preference of landraces over hybrid eggplant fruit		WTP Model
	Coefficient (Std. Error)	Marginal effect	Coefficient (Std. Error)
Intercept	0.618 (0.416)		-2.140 * (1.136)
Dummy for female respondent	-0.065 (0.155)		0.006 (0.410)
Age of respondent (years)	0.014 *** (0.006)	0.003	0.017 (0.014)
Number of members in the household	-0.023 (0.029)		0.067 (0.082)
Dummy for households with children below 14 years	0.072 (0.157)		0.449 (0.416)
Years of schooling by respondent	0.030 * (0.016)	0.005	0.134 *** (0.043)
Dummy for respondent's ability to identify the landrace products	0.265 * (0.155)	0.055	1.965 *** (0.429)
Average price paid by the household for eggplant (Rs/kg)	-0.062 *** (0.018)	-0.010	-0.120 ** (0.051)
Annual per capita income of the household (thousand Rs), PCAI	0.010 (0.012)		0.125 *** (0.031)
Square of PCAI	-8E-05 (1E-04)		-6E-04 ** (3E-04)
Dummy for respondent from Kolar and Barddhaman	0.310 * (0.183)	0.051	0.341 (0.444)
Sigma			3.775 (0.193)
Log likelihood	-219.44		-681.43
LR Chi^2 (10)	44.26		108.85
Prob. > Chi^2	0.00		0.00

*, **, *** : Statistically significant at 0.10, 0.05 and 0.01 per cent respectively

Figure 1. Production Possibility Frontier (PPF) for Landraces and Modern Varieties with Outputs Q^L and Q^M under Different Market Conditions

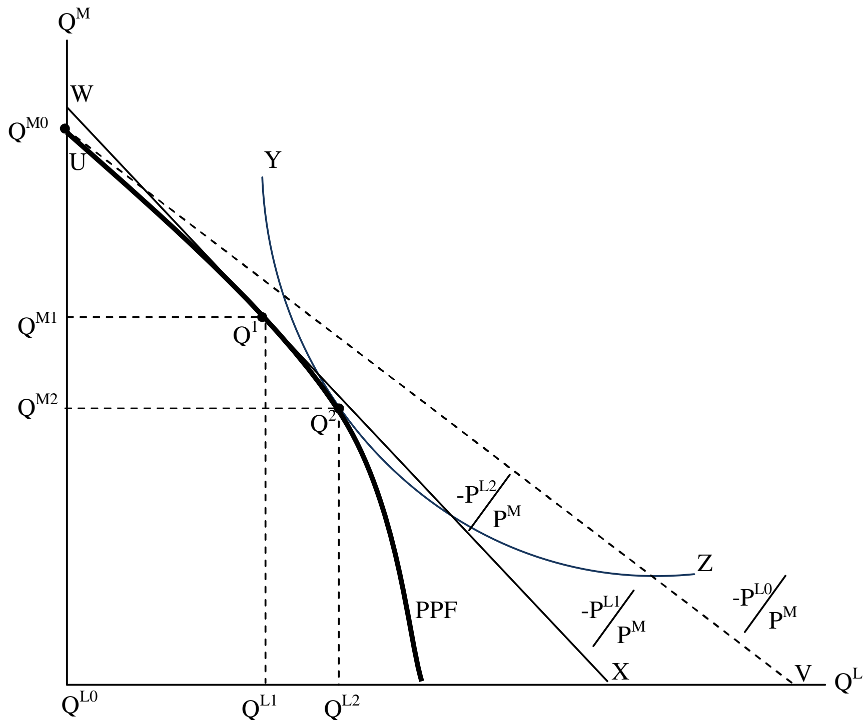

Figure 2.
Consumer WTP for Landrace Eggplant