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Consumers' Perceptions for an Outdoor Ornamental Plant: Exploring the Influence of Novel Plant Diseases Diagnostics and Sustainable Nurseries Cultivation Management

Michel Frem [1], Alessandro Petrontino [2,*], Vincenzo Fucilli [2], Barbara De Lucia [2], Emanuela Tria [2], Adele Annarita Campobasso [2], Federica Calderoni [2] and Francesco Bozzo [2]

[1] Sinagri s.r.l., Spin Off of the University of Bari-Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy; mefrem@sinagrispinoff.it

[2] Department of Soil, Plant and Food Sciences, University of Bari Aldo Moro, Via Amendola 165/A, 70126 Bari, Italy; vincenzo.fucilli@uniba.it (V.F.); barbara.delucia@uniba.it (B.D.L.); emanuela.tria@uniba.it (E.T.); adele.campobasso@uniba.it (A.A.C.); federica.calderoni@uniba.it (F.C.); francesco.bozzo@uniba.it (F.B.)

* Correspondence: alessandro.petrontino@uniba.it

Abstract: A discrete choice experiment was conducted to assess the perceptions and willingness-to-pay of Italian consumers regarding plant diagnosis and sustainable cultivation attributes in outdoor ornamental plants, specifically *Abelia* × *grandiflora*. The results revealed that most Italian consumers place great importance on the health of ornamental plants during the purchasing process, with a preference for obtaining them from nursery facilities. Additionally, they demonstrated a willingness to pay a price premium for innovative plant diagnosis and sustainable cultivation in the production of *A.* × *grandiflora*, amounting to EUR 1.10 and EUR 0.90, respectively. These findings have significant implications for (i) nursery growers, enabling them to shape their sustainable nursery management and marketing strategies, and (ii) policymakers, facilitating the enhancement of communication strategies and the implementation of awareness campaigns aimed at promoting the sale of healthy Italian ornamental species, following the current EU regulation 2020/1201.

Keywords: choice experiment; consumer behavior; innovation; outdoor ornamental plant; quarantine pests; plant marketing; sustainable nurseries cultivation management; *Xylella fastidiosa*

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1. Introduction

1.1. Background and Justification

Plant diagnosis (PD) is a scientific process that involves detecting, identifying, and distinguishing the presence or absence of biotic stresses such as bacteria, viruses, fungi, nematodes, insects, arachnids, and weeds, at various levels of classification, including genus, species, and strain [1]. A specific focus within PD has been the detection of *Xylella fastidiosa* (L.), (Xf hereafter), an invasive polyphagous bacterium that affects approximately 655 plant species [2]. This study expands on previous research in plant pathology, which underscored the significant effects of diseases such as *Xylella fastidiosa* (L.) on ornamental plants, stressing the importance of reliable diagnostic methods [3–5]. Xf has had a significant impact on the Salento area in the Apulia region of southern Italy, causing severe economic, social, and ecological damage [1,6]. As a result, the plant nursery industry in Apulia has experienced negative consequences in terms of productivity and profitability, due to export restrictions on live plants, trees, edible fruits and nuts, shrubs, bushes, and ornamental species from areas affected by Xf [6]. Import controls and inspections have become mandatory in Europe for plants intended for planting and for nurseries in demarcated areas [7]. The introduction of infected plants for planting, primarily from America, is the main driver of Xf introduction into new countries, and the presence of xylem-feeding insect vectors (such as *Philaenus spumarius* and *Neophilaenus campestris*, acting as the primary and secondary Xf vectors in Apulia, respectively) contributes to the local transmission and spread of this harmful bacterium [8]. Consequently, the adoption and implementation of novel plant diagnosis assays, utilizing serological and molecular tests [7], have been crucial for confirming the absence of pathogenic organisms like Xf in potted ornamental species, which is essential for regulatory decisions, reestablishment of pest-free areas, trade purposes, effectiveness of pest eradication strategies, pest risk analysis, and addressing consumer concerns.

In addition to plant diagnosis, sustainable cultivation techniques (SCT) are seen as essential management tools to improve the quality, productivity, competitiveness, and commercialization of ornamental plants, while also reducing the environmental impact of cultivation processes [9]. Producers, including ornamental firms, increasingly utilize sustainable production methods, green claims, and eco-labeling to align with consumer concerns and gain a competitive advantage [10]. Responsible consumption, consumer preferences, and lifestyles also play a role in influencing producers, such as plant nursery entrepreneurs, to adopt less environmentally harmful inputs and production methods [11]. SCTs encourage nursery growers to prioritize eco-friendly management practices and cost-effective resource and input usages, including water, electricity, land, growing media, pots, pesticides, fertilizers, and labor, thereby contributing to a more sustainable plant production system, and potentially benefiting the Italian nursery sector. In ornamental cutting propagation, the utilization of biostimulants (i.e., seaweed extracts, as an alternative to synthetic auxins) to improve adventitious roots formation and promote balanced shoots aligns with the principles of sustainability and eco-friendly production [12,13]. However, understanding consumers' willingness-to-pay (WTP) for SCTs is crucial to achieve this goal.

1.2. Literature Review

The most recent literature exploring innovation in technologies for plant diagnostics and sustainable cultivation techniques provided a contemporary framework for our analysis.

In terms of plant diagnostics, Ali et al. [14] provided valuable insights into the use of biosensors (i.e., isothermal amplification, nanomaterials, robotics, lab-on-a-chip devices) as effective emerging tools for early detection of plant pathogens in agriculture, while the conventional laboratory-based methods are costly, time-consuming, and require specialized skills. In addition, Dheeraj et al. [15] proposed a novel appropriate technique in their study (i.e., a lightweight dense net model, LWDN), based on the Dense Net 121 architecture, for real-time plant diagnosis on portable and mobile devices with limited computational resources, contributing to sustainable agriculture and food security. In their paper, Sharma et al. [16] proposed also a new smart plant leaf disease detection technique (i.e., a deeper lightweight convolutional neural network architecture, DLMC-Net) for several crops for real-time agricultural use on simple leaf images of both healthy and diseased plants, contributing to effective disease management in agriculture. In addition, Fan et al. [17] suggested a leaf image-based disease recognition tool in their research, using transfer learning and feature fusion, advancing the fight against agricultural biotic threats and ensuring healthier crops. Moreover, Dhaka et al. [18], in their review, provided valuable insights into the integration of Internet of things (IoT) and deep learning models as powerful tools for addressing the automatic detection, visualization, and classification of plant diseases. In their review, Jafar et al. [19] delved into the critical role of accurate and rapid plant disease detection, such as the combination of artificial intelligence (AI) with IoT platforms such as smart drones for field-based disease detection and monitoring, enhancing long-term agricultural yields. Furthermore, Devi et al. [20] reviewed the common detection techniques of plant viruses (i.e., ELISA, Western blot, dot blot, immuno-fluorescent assay) and stressed the considerable progress made in microarray and next-generation sequencing detection of plant diseases, like LAMP (loop mediated isothermal amplification), RPA (recombinase polymerase amplification) and HAD (helicase-dependent amplification), contributing to enhance productivity, improving crop quality, reducing production costs, and mitigating the environmental impact of chemicals in agriculture.

With respect to the use of sustainable cultivation practices, Fuentes-Peñailillo et al. [21] highlighted the groundbreaking potential of next-generation technologies in soilless plant production (i.e., AI monitoring systems that offer accuracy in tracking critical variables like nutrient concentrations and pH levels) and precision farming methods, enhancing precision of resource allocation and farm management. In addition, Li et al. [22] also stressed the considerable potential of soilless cultural systems that maximize the benefits of the greenhouse horticulture environment, enhancing the growth of crops. Moreover, Bantis et al. [23] evidenced the importance of grafting, an eco-friendly technique based on high-quality grafted seedlings, in offering transformative benefits for growers. Furthermore, Huang and Gu [24] also explored the promising use of biochar in optimizing the plant growth in horticulture crop production systems, when used in container substrates. Moreover, Cardoso et al. [25], in their special issue overview, highlighted (i) the relevance of advanced breeding and genetic improvement techniques that lead to better plant ornamental varieties; (ii) the importance of automation, robotics, and precision agriculture that enhance ornamental plant production efficiency; and (iii) the consideration of the biotechnology that allows for genetic modification and improved traits of ornamental plant cultivars. Finally, Daras [26], in his critical review, underscored the importance of cultivating native and specialty ornamental plants to offer eco-friendly alternatives, meeting future consumer needs, while implementing sustainable practices.

Concerning consumer behavior, numerous papers have examined consumer preferences for ornamental plants [27–30]. While many studies focused on various attributes influencing purchasing decisions, only a limited number specifically investigated the significance of aesthetic aspects and physical factors, local production, and eco-friendly cultivation techniques, such as seedling substrates and prices [31]. For example, Wagstaffe et al. [32] examined the impact of intensive cultural practices on the flowering performance of the herbaceous perennial *Coreopsis grandiflora* cv. Flying Saucers, exploring how these practices influenced customers' motivations to purchase and plant the species in their gardens. Palma et al. [33] found that price was the most influential factor in the purchasing decisions of Hawaiian consumers, while color had the least impact on their choice of orchids, using a conjoint analysis approach. Rhin et al. [34] investigated consumer preferences for organic production methods and origin promotions in ornamental species, employing eye-tracking experiments to study visual attention and its influence on decisions regarding indoor foliage and fruit-producing plants. Furthermore, Hovhannisyan and Khachatryan [30] analyzed the influence of socio-economic and demographic factors on the demand for ornamental plants using a theory-based demand model. However, few studies have addressed the factors that impact Italian consumers' preferences or estimated their WTP for specific attributes and types of ornamental species. In this regard, Schimmenti et al. [10] explored the behavior of Italian consumers in relation to conventional and organic flowers and ornamental plants, employing a behaviorist approach based on an econometric probit model.

1.3. Aims and Research Questions

Within the framework of the Apulian region funded project "ProDiQuaVi" (transfer of protocols for quarantine and harmful organisms and for the selection of sanitary materials improved for the Apulian nursery) (www.prodiquavi.it, accessed on 14 April 2021), we conducted a preliminary investigation to examine whether potted ornamental plants, diagnosed and produced through a sustainable cultivation cycle, could command a price premium compared to those without phytosanitary diagnostics and conventional cultivation techniques. Our study focused on *Abelia* × *grandiflora*, created by crossing the wild species *A. chinensis* and *A. uniflora* (*Caprifoliaceae* family), as a case study of an open field grown shrub, due to it being in the top 10 marketed potted species, its evergreen status as a potential feeding plant for Xf vectors, and its economic significance for Italian nursery entrepreneurs. In this direction, this paper addressed three interconnected aspects: (i) Italian consumers' behavior and propensity towards ornamental plants, (ii) their WTP for labelling information regarding potted plant diagnosis and cultivation techniques, and (iii) how their demographic and socio-economic characteristics interact with potted ornamental plant prices.

2. Methodology

Consumers' perceptions towards goods and services are commonly assessed through two categories of economic methods: (i) revealed preference methods (such as market price, cost-based, hedonic pricing, and travel cost), and (ii) stated preference techniques (such as conjoint analysis, CA and DCE). On the one hand, the first category is based on observed consumer attitudes and behavior. On the contrary, the second category assumes a hypothetical situation for consumers to assess their preferences and estimate their WTP. Among these, we opted in this study for the second group of econometric methods, and we mainly considered the DCE, due to its (i) best alignment with and suitability for our hypothetical research objectives; (ii) precision for assessing numerous attributes in which respondents make choices on trade-offs, similarly to how they would decide in actual purchase situations; (iii) great flexibility in attribute design, in which we could include both continuous and categorical attributes, and respondents can choose from various combinations, while the CA method is limited by the flexibility of attribute combinations, as supported by the recent papers of Čop et al. [35], Johansson et al. [36], and Wang et al. [37] as well as Johnston [38]. In addition, the CA has evolved from only two possibilities (i.e., status quo/no-buy and one hypothetical option), with which it is difficult to fully capture the consumer decision making process, while within the DCE approach, consumers have the possibility to choose among two, three, or more hypothetical alternatives, as described below, providing more valuable evidence on consumers preferences and inclinations, and addressing a complex decision-making process. In the following sections, we describe the adopted DCE methodology, which consists of four main steps: (i) determination of attributes and levels, (ii) experimental design and choice set, (iii) social survey, and (iv) econometric models and data interpretation using a multinomial logit model (MNL), random parameters (mixed) logit model (RPL), and a latent class model (LCM).

2.1. Selection of the Attributes and Their Levels

We selected three attributes (Table 1) in alignment with the innovative and sustainability goals of the "ProDiQuaVi" project, with input from a focus group consisting of Italian horticulture experts. The first attribute comprised two levels. The first level is a binary attribute (0, 1), where (1) represents the utilization of a novel plant phytosanitary diagnostic protocol, such as mass RNA sequencing [7] for the rapid detection of quarantine harmful organisms like Xf in plants intended for vegetative propagation. This level offered advantages such as lower costs and shorter detection times. Baseline, on the other hand, denoted the absence of any plant phytosanitary diagnosis in nurseries. The second level is also a binary (0, 1) attribute related to potted plant cultivation methods in nurseries, where (1) referred to a sustainable cultivation technique that included benefits such as a shortened rooting period (−20 days), reduced cutting mortality rate (−20%), and the efficient use of resources and inputs, as outlined in Table 2. The last attribute was the price of potted plants, with of four levels reflecting market ranges taken from a market analysis through Italian sellers. The four levels reflect the upper and lower ranges of the current average nursery selling price for *A.* × *grandiflora* with a diameter of 16 cm.

Table 1. *A.* × *grandiflora* attributes and attribute levels used in this choice experiment.

Attribute (Code)	Level Number	Level
Phytosanitary diagnosis in nursery (Code: diagnosis)	2	(1) Presence (use) of a novel plant phytosanitary diagnostic protocol with low costs and times (2) Absence (non-use) of plant phytosanitary diagnosis
Nursery cultivation technique (Code: technique)	2	(1) Sustainable cultivation technique (2) Conventional cultivation technique
Price (Code: price)	4	(1) EUR 2.00; (2) EUR 4.00; (3) EUR 6.00; (4) EUR 10.00

Table 2. Comparison between conventional and sustainable *A.* × *grandiflora* cultivation techniques used in the choice experiment.

Input or Resource for the *Abelia grandiflora* Cultivation Process	Conventional Cultivation Technique	Sustainable Cultivation Technique
Stock mother plants and cuttings	Use of pot-bred mother plants from previous production cycles carried out at the same nursery level and may not guarantee healthy potted plants	Use of certified planting material from accredited organisms that may guarantee healthy potted plants
Rooting promotors and cutting propagation	Use of chemical plant growth regulator (as a source of auxin only—rooting powder hormone—IBA at a concentration of 0.5% w/w) Massive use of biocontrol fungus	Use of a bio root stimulator and balanced shoots (as a natural source of auxins, cytokinin, polysaccharides, and vitamins) Use of brown seaweed-extract-based biostimulants (at a concentration of 1 mL L^{-1}) Low application of biocontrol fungus
Labor	Requires increased working hours during the production cycle	Requires few working hours during the production cycle
Chemical treatment	Massive use of chemical fungicides	Low application of chemical fungicides
Consumables (pots)	Requires more pots due to a potentially high mortality rate	Requires fewer pots due to a potentially lower mortality rate
Consumables (water, fuel)	Requires greater fuel and water resources due to a relatively high production cycle duration	Requires fewer fuel and water resources due to a relatively low production cycle duration
Whole production cycle duration in days	280 days due to more days for the rooting phase owing to the use of a relative low concentration of bio root stimulators	260 days due to less days for the rooting phase, owing to the use of a relatively high concentration of bio root stimulators

Source: Based on Frem et al. [39] and Loconsole et al. [13].

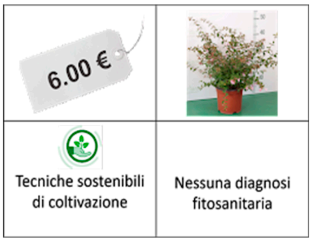
2.2. Experimental Design and Choice Set

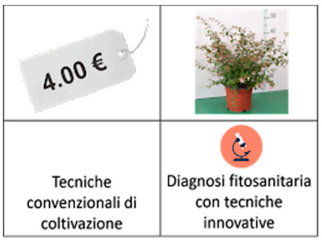
The selected attributes and their corresponding levels (Table 1) resulted in a full factorial design of 120 alternative scenarios, which posed operational constraints. To overcome these constraints and the optimize data collection, we employed a D-efficient Bayesian design [40,41] based on a full factorial design obtained with Equation (1), using the AlgDesign package in R software (R-4.4.0). This approach allowed us to improve the data quality, reduce costs and time requirements, and obtain more precise information from the entire population sample participating in the choice experiment [42,43]. By reducing the D-error [44], we ensured a more accurate estimation of consumer preferences. As a result, we generated 16 distinct profiles, representing choice sets, organized in a single block consisting of 8 choice sets. The order of options within each choice set was randomized [45] and supported by visual images, pictograms, and verbal descriptions of the attributes of concern [46,47]. These choice sets were specifically designed for Abelia grandiflora plants with a diameter of ø16 cm. Each choice set presented two options (Option A and Option B), as well as an additional Option C, which allowed respondents to choose neither option A nor option B (referred to as "no-buy" or "no choice"), as depicted in Table 3.

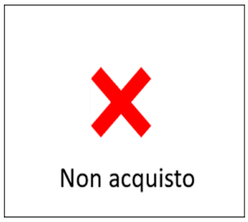
$$\mathrm{N} = \frac{\mathrm{Jn}\ (\mathrm{Jn} - 1)}{2} \tag{1}$$

where N is the number of possible combinations of alternatives, J_n corresponds to $2^2 * 4^1$, whereby 2 attributes (e.g., "diagnosis" and "technique") had 2 levels and 1 attribute ("price") presented 4 levels, as illustrated in Table 1.

Table 3. Example of a choice set used in this choice experiment.







Sustainable cultivation technique	Absence (non-use) of plant phytosanitary diagnosis	Conventional cultivation technique	Use of a novel plant phytosanitary diagnostic protocol	No-Buy
I opt for:	☐ Option A	☐ Option B		☐ Option C

2.3. Sampling and Social Survey

We initially calculated a target representative sample size (n) of 385 Italian respondents according to the common Equation (2) for sampling. Then, we conducted an online social survey using a questionnaire (Supplementary Material File—Questionnaire S1) from June 2021 to June 2022, from which we obtained 520 questionnaires. Finally, we retained for our econometric analysis 464 valid and complete responses, representing an increase of 20% over the target number of respondents that needed to be initially included in our analysis.

$$\mathrm{n} = \frac{\frac{z^2 * p(1-p)}{e^2}}{1 + \left(\frac{z^2 * p(1-p)}{e^2 * N}\right)} (2) = \frac{\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2}}{1 + \left(\frac{1.96^2 * 0.5(1-0.5)}{(0.05)^2 * 50{,}208{,}329}\right)} = 385 \text{ respondents at least}$$

where n is the sample size. N is the Italian population size over 18 years old (N = 50,208,329 in the 1st of January 2021 based on ISTAT [48]). e: is the margin of error (percentage in decimal form: 5%). z: is the z-score (z = 1.96 for a desired confidence level of 95%). p: is the standard deviation (p = 0.5)

The questionnaire was divided into three sections (Supplementary Material File—Questionnaire S1). The first section included questions about the respondent's habits and propensity to purchase ornamental plants. In the second section, each respondent was presented with eight purchase simulations. They had the option to choose one of the two plants proposed in pots ø16 cm in diameter (Option A and Option B) with different characteristics and prices, or they could choose not to buy any of the options proposed (Option C), as described in Section 2.2 and Table 3. The third section aimed to gather demographic and socio-economic information. We ensured that all respondents were informed at the beginning of the survey that their provided information would remain anonymous and be used exclusively for this research. We also assured them that we would adhere to the regulations of the EU Regulation (EU 2016/679).

2.4. Econometric Models

MNL (multinomial logit) is based on the utility maximization function [42], which assumes that respondents will choose the alternative (A, B, or C as mentioned above) that maximizes their utility. In our study, the choice of the potted outdoor plant was influenced by its attributes ("diagnosis", "technique", and "price"), as well as the perceptions that distinguish the respondent. These choices are also constrained by imperceptible parameters such as socio-demographic and economic variables, which are considered random variables in this context.

The utility function (Unj) for the j-th alternative of the n-th respondent is composed of a deterministic component (Xnj) that depends on observable attributes and a stochastic component (ε) that represents measurement errors and captures all the unobservable attributes that influence the purchase decision. Therefore, the utility function can be expressed as follows:

$$U_{n,j} = V_{n,j} + \varepsilon_{n,j} = \beta' X_{n,j} + \varepsilon_{n,j} \quad (2)$$

where "U" refers to the utility, "$\beta'X$" the deterministic part, "ε" the random part, "n" the respondent, "i" the alternatives, and "j" the choice set.

Hence, this utility function in this study was modelled as follows:

$$V_{n,\text{Option A}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (3)$$

$$V_{n,\text{Option B}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (4)$$

$$V_{n,\text{Option C}} = \beta'_1 * \text{diagnosis} + \beta'_1 * \text{technique} + \beta'_1 * \text{price} \quad (5)$$

where attributes (e.g., "diagnosis", "technique", and "price") are described in Table 1. Consequently, the possibility that the n-th respondent selected the i-th alternative from choice set "j" is determined as follows:

$$Prob\ n, i = \frac{\exp(Vni)}{\sum_{j=1}^{J} J\exp(Vni)} \quad (6)$$

Therefore, standard MNL assumes similar attitudes and choice homogeneity among respondent preferences, showing an important drawback of this model. Consequently, a set of complex econometric models, such as RPL and Latent Class Model are often applied to relax the homogeneity assumption and to capture the heterogeneity of non-observable preferences, whereby the deterministic part of the utility can be modelled as follows:

$$U_{n,j} = V_{n,j} + \varepsilon_{n,j} = (\beta' + \eta n) X_{n,j} + \varepsilon_{n,j} \quad (7)$$

where β' denotes the mean value attribute utility weight in the sample and ηn is the vector of person n-specific difference from the mean.

Concerning the RPL model, Halton draws were used to estimate the model, because this provides a more efficient distribution of draws for numerical integration [49]. Regarding WTP, we assumed a linear function of the utility, so that the respondents are willing to pay a price premium for each attribute (Table 1) based on the following equation:

$$WTP_A = -\frac{\beta_A}{\beta_P} \quad (8)$$

where β_A and β_P are the estimated coefficients related to each attribute and price, respectively.

Furthermore, an LCM was employed to investigate different behaviors among respondents, segment the market, and estimate consumer profiles. The LCM allowed the researchers to group consumers into different classes based on their purchasing choices. To determine the optimal number of classes, information criteria values such as maximum log likelihood, minimum Bayesian information criteria (BIC), and minimum corrected Akaike criteria (CAIC) were evaluated. By gradually increasing the number of classes, the model achieved an improved fit and performance in terms of stability, sensitivity, and specificity.

3. Results

3.1. Descriptive Statistics Results

The descriptive statistics results regarding Italians' behavior and propensity towards ornamental plants revealed some interesting insights. Many respondents preferred to acquire horticultural plants directly from nurseries (31%) and from specialized shops/florists (30%), followed by shopping malls (16%). When it came to the aspects of ornamental plants that received the most attention from Italian consumers, apart from prices and cultivation methods, a significant percentage of respondents expressed a high level of interest in the state of health (71%), care requirements (51%), water requirements (39%), plant luxuriance (52%), and absence of visible defects on leaves and stems (62%). Regarding the care of ornamental plants, the data indicated that most respondents (49%) preferred to take personal care of the plants they purchased, without seeking external advice from specialists in the field.

3.2. Econometric Results

The following econometric models were obtained with the software NLOGIT version 5. Table 4 presents the results of the MNL model, revealing interesting findings. All coefficient estimates associated with the attributes showed positive signs, except for the price, as was expected. Furthermore, these coefficients were highly significant at the 1% level. Additionally, the alternative specific constant (ASC) for the opt-out option (option C—no buy) was determined to be −0.33, and its significance was also high. This suggests that the respondents had a positive approach to the analyzed product. The coefficients for the "diagnosis" and "technique" attributes, as described in Table 1, were positive and highly significant ($\rho = 0.00$). This indicates that the inclusion of plant diagnosis, monitoring, and environmentally friendly cultivation practices in nurseries instilled a strong sense of trust and generated significant utility for the studied population.

Table 4. Multinomial logit (MNL) and random parameter logit (RPL) model performance estimates.

	MNL	RPL
Log likelihood function (L)	−3880	−3258
Number of independent variables (K)	4	33
Akaike information criterion (Inf.Cr.AIC)	7768	6853
Bayesian information criterion (BIC)	7792	6788

The RPL model, obtained with 200 Halton draws, yielded favorable results in terms of the log likelihood function, information criteria AIC, AIC/N, and BIC compared to the MNL model. Additionally, the attributes obtained from the RPL model were consistent with those from the MNL model, reaffirming the disutility experienced by Italian consumers when faced with the no-choice alternative. Moreover, all attribute coefficients were statistically significant at the indicated levels of significance (* $\rho < 0.10$; ** $\rho < 0.05$; *** $\rho < 0.01$), and their signs aligned with those obtained from the MNL model (Table 5). This further emphasizes the significance of "diagnosis" and "technique" practices for Italian consumers when making purchasing decisions for potted ornamental plants, resulting in increased utility for them.

Table 5. Random parameter logit model (RPL) and multinomial logit model (MNL) coefficient estimates.

MNL							
Code of the Attribute (as Described in Table 1)	**Coefficient**		**Standard Error**	**z**	**Prob. |z| > Z ***	**95% Confidence Interval**	
Diagnosis	0.97	***	0.09	10.49	0.00	0.79	1.15
Technique	0.75	***	0.07	10.79	0.00	0.61	0.88
Price	−0.1	***	0.01	−8.68	0.00	−0.13	−0.08
Alternative specific constant ASC (Opt-out)	−0.33	***	0.06	−5.13	0.00	−0.45	−0.2
RPL							
Random Parameter	**Coefficient**		**Standard Error**	**z**	**Prob. |z| > Z ***	**95% Confidence Interval**	
Price	−1.15	***	0.13	−8.69	0.00	−1.41	−0.89
Nonrandom parameters							
Diagnosis	1.27	***	0.1	12.35	0.00	1.07	1.48
Technique	1.03	***	0.08	12.77	0.00	0.87	1.19
Alternative specific constant ASC (Opt-out)	−1.09	***	0.08	−13.42	0.00	−1.25	−0.93

Note: *, *** ==> Significance: at 90%, 99% level, respectively.

Price was used as a random parameter following a normal distribution. Furthermore, the analysis of interaction effects (Table 6) between the price attribute and various parameters related to the consumers' behavior, propensity to purchase ornamental plants, demographic factors, and socio-economic characteristics provided valuable insights for understanding the heterogeneity of consumer perceptions and preferences for potted ornamental plants, such as *A.* × *grandiflora*. Regarding the frequency of purchase, it was discovered that Italian consumers who are inclined to buy potted ornamental plants more than once a month are more affected by price. In terms of the preferred place of purchase, respondents showed a strong influence from direct purchases from nurseries. Interestingly, trust in nurseries emerged as a significant driver for potted plant purchases. This suggests that nurseries can play a vital role by providing information about their plant production practices and highlighting their commitment to sustainability. In terms of demographic parameters, the analysis revealed that gender and age had a relatively limited impact on the price purchase of potted plants. However, level of education appeared to play a significant role in determining price sensitivity among consumers.

With respect to the WTP, respondents were willing to pay an additional EUR 1.00 (Table 7) for changes in the production of outdoor plants, specifically *A.* × *grandiflora*. The WTP for different attributes of ornamental production systems varied slightly, with a WTP of EUR 1.10 for plant diagnosis and EUR 0.90 for cultivation techniques used in nurseries, indicating a strong consumer preference for plant health and a significant interest in sustainability in the nursery industry.

Regarding the latent class results, the analysis was performed with different numbers of classes ranging from 1 to 6. For each number of classes, the log likelihood and information criteria were computed, including the Inf.Cr.AIC, AIC/N and adjusted BIC. The results show that as the number of latent classes increased, the log likelihood decreased, indicating a better model fit, but reducing the consistency of each class and complicating the overall model. It appears that the model with five latent classes (K = 5) had the lowest log likelihood (−2979) and was the best fit according to the information criteria. The percentage of the sample assigned to each of the five classes is provided, ranging from 8% to 31%. The log likelihood of the model with five classes compared to a restricted one performing a significant chi-squared test and the McFadden pseudo-R-squared indicated a moderate level of fit. Each class had different utility parameters for the predictor variables. Post-elaboration analysis allowed for the interpretation of the behavior and characteristics of each class based on the following table and the descriptive statistics of each class. The segmentation analysis was conducted by considering the covariates, resulting in significant differences across classes. The study identified five distinct classes based on respondents' characteristics and behavior (Table 8).

Table 6. Interaction of demographic parameters and consumer covariates with price as a random normal distributed parameter in RPL model.

Heterogeneity in Mean	Coefficient	Standard Error	z	Prob. ∣z∣ > Z *	95% Confidence Interval	
Price × Frequency						
Rarely	0.25 **	0.10	2.51	0.01	0.05	0.45
Once a year	0.39 ***	0.11	3.55	0.00	0.18	0.61
More than once a year	0.33 ***	0.11	3.19	0.00	0.13	0.54
Once a month	0.47 ***	0.12	4.01	0.00	0.24	0.70
More than once a month	0.59 ***	0.13	4.48	0.00	0.33	0.85
Price × Place of purchase						
E-commerce	0.20 *	0.16	1.26	0.21	−0.11	0.51
Peddler	0.27 ***	0.10	2.58	0.01	0.06	0.47
Shopping mall	0.24 ***	0.09	2.62	0.01	0.06	0.42
Specialized shop/florist	0.28 ***	0.09	3.20	0.00	0.11	0.45
Garden center	0.19 *	0.11	1.75	0.08	−0.02	0.41
Nursery (direct producer)	0.30 ***	0.09	3.38	0.00	0.13	0.48
Price × Gender						
Gender (male)	0.06 *	0.04	1.62	0.10	−0.01	0.13
Price × Age						
Age	0.00 *	0.00	−1.43	0.15	0.00	0.00
Price × Level of education						
Year of study	0.01 **	0.00	2.20	0.03	0.00	0.02

Note: *, **, *** ==> Significance: at 90%, 95%, 99% level, respectively.

Table 7. Willingness-to-pay estimates.

Attribute	EUR
Phytosanitary diagnosis in nursery (Code: diagnosis)	1.10
Nursery cultivation technique (Code: technique)	0.90
Overall average	1.00

The first class, comprising 21% of respondents, showed a positive price coefficient and a high frequency of purchasing. They preferred buying from nurseries or direct producers and placed high importance on quality aspects, but not on price. They personally cared for plants and predominantly lived in houses with private green spaces. This class consisted of educated individuals with a medium-high income.

The second class, representing 30% of respondents, exhibited a medium-high willingness to pay for both attributes and preferred sustainable cultivation techniques. They made moderately frequent purchases from florists and garden centers. Their attention during the purchase aligned with their willingness to pay, focusing on care and absence of defects. They also lived in houses with private green spaces and had a higher education level and medium income.

The third class accounted for 19% of the sample and showed a positive but limited willingness to pay. They were occasional buyers who did not prioritize a specific place of purchase and primarily sought low prices. They disregarded cultivation methods, care, and water requirements of plants. Their education level was medium-high, and they did not predominantly live in contexts with private green spaces.

Table 8. Latent class analysis (LCA) results.

Variable ∣Class∣	Coefficients	Standard Error	z	Prob. ∣z∣ > Z *	95% Confidence Interval	
Price ∣1∣	0.14830 **	0.05815	2.55	0.0108	0.03433	0.26228
Diagnosis ∣1∣	3.34491 ***	0.3965	8.44	0	2.56778	4.12203
Technique ∣1∣	1.46855 ***	0.30707	4.78	0	0.86671	2.07038
Opt-out ∣1∣	−0.02551	0.414	−0.06	0.9509	−0.83694	0.78591
Price ∣2∣	−0.11389 ***	0.03094	−3.68	0.0002	−0.17454	−0.05325
Diagnosis ∣2∣	0.69281 ***	0.20196	3.43	0.0006	0.29698	1.08864
Technique ∣2∣	1.11086 ***	0.15424	7.2	0	0.80855	1.41318
Opt-out ∣2∣	−1.79515 ***	0.32509	−5.52	0	−2.43232	−1.15797
Price ∣3∣	−0.82441 ***	0.11607	−7.1	0	−1.0519	−0.59691
Diagnosis ∣3∣	0.88302 **	0.34764	2.54	0.0111	0.20166	1.56438
Technique ∣3∣	1.19945 ***	0.33337	3.6	0.0003	0.54605	1.85284
Opt-out ∣3∣	−4.16053 ***	0.45458	−9.15	0	−5.05149	−3.26957
Price ∣4∣	−0.13416 ***	0.03921	−3.42	0.0006	−0.21102	−0.05731
Diagnosis ∣4∣	1.80417 ***	0.30992	5.82	0	1.19674	2.41159
Technique ∣4∣	1.26312 ***	0.20934	6.03	0	0.85281	1.67343
Opt-out ∣4∣	1.20360 ***	0.229	5.26	0	0.75477	1.65244
Price ∣5∣	−0.24909	0.3517	−0.71	0.4788	−0.93841	0.44022
Diagnosis ∣5∣	−0.14798	1.57975	−0.09	0.9254	−3.24423	2.94828
Technique ∣5∣	−2.04314	1.72048	−1.19	0.235	−5.41523	1.32894
Opt-out ∣5∣	2.90442 ***	1.00348	2.89	0.0038	0.93764	4.87121

Note: ***, **, * ==> Significance at 1%, 5%, 10% level.

The fourth class, representing 20% of the sample, consisted of relatively rare buyers who occasionally preferred florists over nurseries. Despite not expressing clear attention to specific aspects, their willingness to pay was high, likely influenced by the low frequency of their purchases. They showed a preference for phytosanitary diagnosis techniques rather than sustainable cultivation techniques.

The fifth and smallest class, comprising 8% of respondents, demonstrated a strong aversion towards the analyzed product. They had a high and positive coefficient related to non-purchase, indicating no willingness to pay for the analyzed attributes. They rarely made purchases, did not care for plants at home, and lacked houses with green spaces. This class had the lowest proportion of individuals with a diploma, indicating lower education and income levels compared to other classes.

4. Discussion and Conclusions

4.1. Key Findings at a Glance

In this paper, we assessed, through a sample of 464 reasonable Italian respondents, their perceptions and WTP for an outdoor ornamental plant, *Abelia* × *grandiflora,* as a case study of an open field grown shrub and considered a high potential feeding plant for Xf vectors [49], by investigating the effect of (i) novel plant diseases diagnostics (i.e., "diagnosis") through early detection of potential diseases such Xf, and (ii) sustainable nursery cultivation management (i.e., "technique"), reducing environmental impacts. Here, we link the key findings for the research questions of the study. In this direction, we found that most respondents (71% of the sample) considered the health status when buying ornamental plants. In addition, the choice of cultivation method in nurseries had a relatively smaller impact on their purchasing decision. Interestingly, consumers were less likely to seek the advice of trusted experts or rely on the presence of a gardener/maintenance worker when purchasing ornamental species like *Abelia* × *grandiflora*.

In addition, the attributes "diagnosis" and "technique" had positive and highly significant (ρ = 0.00) coefficients, suggesting that the incorporation of environmentally friendly cultivation procedures, plant diagnosis, and early detection, as well as continuous monitoring in nurseries, created a great sense of confidence and produced a substantial amount of benefit for the population under study, as depicted by the means of the MNL and RPL outcomes in Table 5. Moreover, we found that respondents, on average, were willing to pay a price premium for innovative plant diagnosis and sustainable cultivation in the production of *Abelia* × *grandiflora*, amounting to EUR 1.10 and EUR 0.90, respectively, as estimated in Table 7, illustrating that they had a relatively higher degree of interest in plant health over the sustainability issues of ornamental plants they buy, in order to maximize their satisfaction. Furthermore, this paper revealed the existence of five *Abelia* × *grandiflora* respondent segments, which are pertinent for supporting the Italian plant nursery sector, based on their socio-economic and demographic characteristics, as well as attitudes, as evidenced by the outcomes of the LCA depicted above, in which the largest segment, represented by 30% of the respondents, denoted medium-high willingness to pay, especially for sustainability, and frequently buy from florists and garden centers. In this segment, participants prioritized plant care and lack of defects, had higher education, medium income, and lived in houses with private green spaces.

4.2. Importance and Implications of the Findings

The results explored above provide a clear picture of Italian consumers' perception and WTP for an outdoor ornamental plant regarding plant diseases and eco-friendly plant cultivation practices, such as the optimal use of plant stimulators and reduced resource and input usage. Here, we derive some private and policy implications from our findings. First, our research highlights that a significant majority of respondents were willing to pay a 20% premium for plants certified as disease-free, protected from every possible biotic stress such Xf that can befall them. Similarly, our study revealed a considerable number of respondents that favored sustainable cultivation practices for outdoor ornamental plants. The absence of such research for the Italian plant nursery industry is a critical constraint on the expansion of current knowledge regarding consumer choice behavior for non-edible outdoor potted plants, as there is a lack of scientific papers that have simultaneously examined phytosanitary diagnosis and sustainable cultivation attributes using a DCE approach. Second, our paper provides valuable insights for the Apulian plant nursery sector, by helping the nursery managers to plan their plant production management through the adoption of sustainable and disease-preventive practices, and by develop effective marketing strategies for their ornamental species and prioritizing certifications and labelling for plant disease-free and sustainability. Moreover, the segmentation of participants through the mean of the LCA outlined the main characteristics of consumers interested in ornamental plants, and consequently can contribute toward better positioning strategies for nursery products to compensate for higher costs related to production requirements. Lastly, the research findings are crucial for policymakers to formulate communication strategies and awareness campaigns, in order to promote the sale of healthy Apulian ornamental species in compliance with the current EU regulation 2020/1201, which requires mandatory inspections and control of quarantine pests such as Xf on plants propagated in nurseries located within the demarcated area of the outbreak of the pest.

4.3. Comparison of the Findings

The descriptive statistics findings reported in Section 3.1 align with previous studies [50–55], which highlighted consumers' preferences for visible aesthetic qualities and features of ornamental plants (i.e., plant health, shape, flower and leaf color, final height, etc.). Additionally, our findings are consistent with Schimmenti et al. [10], who found that purchases of cut flowers and potted plants were commonly made in nurseries and flower shops. In contrast, Yue and Behe [56] demonstrated that consumer purchasing behavior for ornamental plants was more likely to occur in mass-merchandisers rather than garden centers. In terms of WTP, Yu et al. [57] investigated the WTP of US and Canadian consumers for sustainable attributes in ornamental plants (i.e., Chrysanthemum) and found a lower WTP of USD 0.11. Previous studies also highlighted the influence of environmental labelling information on consumers' likelihood of purchasing ornamental plants, explored the importance of pest management practices and price in consumers' purchasing decisions and WTP for floriculture crops, and examined the demand for visually attractive and novel ornamental plants [57,58]. Moreover, Frem et al. [39] found an average annual gross margin of around EUR 0.20 per ornamental plant, such as *A.* × *grandiflora*, when using sustainable cultivation methods compared to conventional ones.

4.4. Limitations of the Study and Future Research Areas

The sampling approach used in this research might not permit generalizing the observed findings over the rest of the country. Thus, future research could use a multistage or a stratified sampling method dividing the Italian population into homogeneous subpopulations (i.e., strata) that would differ in gender, age, ethnicity, geographical origin (i.e., city versus rural areas), and income ranges, allowing drawing more precise conclusions across the country and ensuring that every subgroup of consumers is properly represented in the study. In addition, other outdoor and indoor ornamental plants were not included when exploring the consumers' perceptions toward the specified attributes. Therefore, an expansion of the research could certainly go a long way toward filling these limitations. Since this study focused on Italian consumers' preferences for outdoor ornamental plants, it would be valuable to expand the research to include members of specialist plant societies. This would ensure a deeper understanding of the impact of novel plant disease diagnostics and sustainable nursery cultivation methods, as well as a more comprehensive coverage of the market through targeted social media campaigns. Moreover, a possible future direction of research could be to investigate the propensity of nursery companies to embrace emerging technologies and the necessary technical adaptations to improve the sustainability and health security of their production. Furthermore, the results suggest the potential for future analysis using latent class segmentation to uncover valuable insights into different market segments with varying preferences for purchasing various ornamental plants species. Furthermore, a future exploration of the economic viability of introducing sustainable and disease-resistant techniques on a large scale in nurseries would confirm the WTP of customers to pay the higher prices reported in this study.

To conclude, the phytosanitary diagnosis of ornamental plants has become increasingly crucial for Italian nurseries, particularly in the Apulia region due to global plant trade restrictions resulting from the severe outbreak of Xf that occurred in 2013. This situation has emphasized the need for innovative, cost-effective, and time-efficient plant pest quarantine diagnosis methods. Providing labelling information about plant health and environmentally friendly cultivation methods can significantly influence consumers' preferences and raise awareness about plant health and production. Nurseries, greenhouse garden centers, and plant retailers who effectively communicate this information would have a competitive advantage in driving sales of ornamental species. Finally, the implementation of a plant diagnosis protocol could generate a premium compared to the non-use of plant phytosanitary diagnosis in nurseries. In this line, nursery entrepreneurs would need to ensure profitability and economic sustainability to adopt these practices. As evidenced in this paper, the moderate price premium associated with these attributes could potentially cover the additional costs of implementing sustainable cultivation practices.

Supplementary Materials: The following supporting information can be downloaded at https://www.mdpi.com/article/10.3390/horticulturae10050501/s1, Questionnaire S1: Survey on Italian consumers preferences towards ornamental plant diagnosis and sustainable cultivation management.

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Informed Consent Statement: The data collected through the online questionnaire were used exclusively for statistical purposes and for this study. They will not be disclosed to third parties or used for private interests, our own or others, according to Regulation (EU) 2016/679 on the protection of individuals regarding the processing of personal data. The acquired information was exclusively used in an aggregate way, thus guaranteeing the complete anonymity of the respondents.

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