

RESEARCH ARTICLE

Buying better biosecurity: Plant-buying behaviour and the implications for an accreditation scheme in the horticultural sector

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Societal Impact Statement

The horticultural trade relies on healthy plants to flourish. However, its very nature means that it is also a key pathway for the introduction and spread of plant pests and diseases. These pests and diseases threaten horticultural stakeholders, and can also cause huge ecological and economic damage. A horticultural sector accreditation scheme, underpinned by best biosecurity practice, could help reduce these threats. Drawing on survey responses, this study examines the plant-buying habits of UK consumers and their appetite for a horticulture accreditation scheme. We consider the necessary scope of such a scheme and outline how it could be made appealing to the plant-buying public.

Summary

- Movement of live plant material through the horticultural trade is a recurrent pathway for the introduction and spread of pests and diseases. An accreditation scheme underpinned by best biosecurity practice represents one approach to mitigating this risk. This research aims to determine whether an accreditation scheme would likely be supported by the public in the United Kingdom—a factor which would heavily influence its establishment and impact.
- Consumer attitudes and behaviours were elicited through a survey of the UK's plant-buying public ($n = 1,500$). The survey explored awareness of pests and diseases, the importance of biosecurity when making plant-buying decisions (relative to other factors), and appetite for accredited products, including plants.
- The sample exhibited limited awareness of plant pests and diseases and ascribed little importance to biosecurity during plant-buying decisions. Instead, these decisions are influenced by “quality”—a factor also cited to explain consumers' selection of (non-horticultural) accredited goods over unaccredited varieties. Despite apparent support of a horticultural accreditation scheme's ideals, consumers expressed concern that accreditation could lead to more expensive products.
- Public support for a scheme aiming to safeguard the wider environment from pests and diseases is unlikely to materialize without dedicated efforts to raise

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awareness by key influencers such as retailers. However, an assurance of high-quality, healthy plants would increase a scheme's appeal. Furthermore, given the diversity of sources from which plants are obtained, any would-be scheme must encompass a range of growers and sellers if it is to be widely considered by the plant-buying public.

KEYWORDS

accreditation, biosecurity, consumer, horticulture, plant health

1 | INTRODUCTION

The large-scale movement of live plant material through horticultural trade networks has been instrumental for the introduction and spread of tree pests and diseases (Ivors et al., 2006; Pautasso et al., 2010; Schlenzig, Campbell, & Chard, 2015). In the United Kingdom alone, the introduction and spread of *Phytophthora ramorum* and *Hymenoscyphus fraxineus* (the causal agent of ash dieback) have been attributed to this pathway (Brasier, 2008; Chavez, Parnell, & Bosch, 2016). Furthermore, the activities of individual sub-sectors, namely plant nurseries, are considered a substantial risk for the introduction and spread of future threats, including the bacterial pathogen, *Xylella fastidiosa*, which already impacts horticultural crops in mainland Europe (Jeger, Stancanelli, & Pautasso, 2016).

Such introductions can have devastating effects for the host species, though these impacts may extend to additional species and habitats as host ranges expand (Dart & Chastagner, 2007; Denman, Kirk, Brasier, & Webber, 2005; Frankel, 2008; Frankel & Palmieri, 2014; Freer-Smith & Webber, 2017; Hansen, Parke, & Sutton, 2005; Harwood, Xu, Pautasso, Jeger, & Shaw, 2009; King, Harris, & Webber, 2015; Tooley & Kyde, 2007; Tooley, Kyde, & Englander, 2004). Not only do pest and disease introductions risk ecological damage, economic losses can occur through reductions in horticultural and timber stock, decreases in property values due to dead and dying trees, and the allocation of resources for monitoring, tracking and containment efforts (Frankel & Palmieri, 2014; King et al., 2015). The mass felling of the important commercial timber species Japanese Larch (*Larix kaempferi*) in Scotland and Wales owing to *P. ramorum* serves as one such example (Frankel & Palmieri, 2014). Quantifying the total economic cost resulting from a pest or disease also requires an appreciation of lost benefits, such as water and air purification and carbon sequestration. When these factors were included in an attempt to calculate the total economic cost arising from the Great Britain's ash dieback outbreak, the resulting estimate was £15 million—a third more than the reported cost of the country's foot-and-mouth disease outbreak in 2001 (Hill et al., 2019). Furthermore, loss of recreational, cultural, and spiritual resources often cherished by the public are also frequently reported following outbreaks of tree pests and diseases (Porth, Dandy, & Marzano, 2015; Stancanelli et al., 2015; Fuller, Marzano, Peace, Quine, &

Dandy, 2016; Dandy, Marzano, Porth, Urquhart, & Potter, 2017; Forestry Commission, 2017; Jones & Comfort, 2017; Natural England, 2018). Given the potential extent and range of these impacts, it is perhaps unsurprising that over 75% of the UK public feel action should be taken by woodland managers and authorities to protect trees from damaging pests and diseases (Fuller et al., 2016; Forestry Commission, 2017).

With the propensity for further pest and disease introductions and spread heightened through the growth of international trade and changing climatic conditions (Garrett et al., 2016; Hulme, 2017), those in the plant trade are increasingly being called upon to improve their biosecurity practices for their own interest, and to protect natural ecosystems (Brasier, 2008; Schlenzig et al., 2015). In parallel, there have been calls for better communication and engagement among plant buyers, traders, and woodland owners to develop preventative or mitigating actions (Marzano, Dandy, Bayliss, Porth, & Potter, 2015), as well as proposals for monitoring programs at key points of the horticultural supply chain (Chavez et al., 2016). In Australia, these suggestions have been met through the Nursery Industry Accreditation Scheme of Australia (NIASA) which requires adherence to best biosecurity practices during the management of crops, water, and sites in a bid to reduce incidences of diseases such as *Phytophthoras* (Hardy, 2016). In the UK, the emergence of the Horticultural Trade Association's Plant Healthy initiative—aimed at growers, retailers, and landscapers—demonstrates similar ambitions. Although factors such as economics and reliability will likely influence where nurseries opt to procure plants from, consumer demand and a desire to safeguard the wider environment will play a role in determining industry's interest and uptake of an accreditation scheme, and ultimately its impact.

This paper thus focuses on understanding the behaviour of plant buyers, the drivers influencing their decision making, and their attitudes toward a plant health accreditation scheme underpinned by best biosecurity practice. Specifically, we consider whether the plant-buying public is aware of the need for biosecurity measures, and whether they would support a scheme designed to minimize the introduction and spread of pests and diseases by opting to purchase products from an accredited source. Finally, we use these findings to consider the likely implications for an emerging scheme in terms of scope, appeal, opportunities, and challenges.

2 | METHODS AND MATERIALS

2.1 | Survey design and sampling

To address the research aims a survey composed of 20 questions was organized into four sections; demographics, plant-buying habits and drivers, awareness of tree/plant pests and diseases, and attitudes toward accreditation (Figure S1). To ensure that only responses from plant buyers were received, a filter question was employed whereby only those reporting to have purchased plants, trees, shrubs, reeds, grasses, aquatic plants etc. in the past 5 years were permitted to proceed.

Demographic questions were presented in a multiple choice format to gather data on age, gender, and regional location using the categories from the 2011 UK census. Information on the respondents' annual spend on plants was also requested in interval-ratio format. Sources for obtaining plants and the associated drivers employed a multiple choice format with options emerging through discussions with a wider research team and industry experts. Specifically, respondents were asked to identify which sources they obtain plants from as well as the frequency each source was used for obtaining plants. Respondents also ranked up to three sources from which they obtained the greatest quantity of plants. Drivers for plant buying were separated into two questions, both of which offered options approved by the aforementioned consortium. Firstly, respondents were asked to rate the importance of 17 factors when selecting which source to obtain plants from. Secondly, respondents rated the importance of seven factors when deciding which individual plants to buy.

Responses to awareness of tree pests and diseases were self-reported using Likert scales, firstly for the generic threat of newly introduced pests and diseases to the UK's trees and woodlands, and secondly for the threat from eight specific pests and diseases.

Questions on accreditation gave respondents the opportunity to note which accredited products they currently choose to buy, and to select all the reasons why they choose to purchase or avoid accredited products. In addition, respondents were asked to note their reaction to a plant health accreditation scheme, having been presented with a short brief explaining that the biosecurity measures underpinning such a scheme may help to ensure healthier plants and lessen the risk of pests and diseases impacting the wider environment. Finally, respondents were asked how much further they would be willing to travel, and how much more they would be willing to pay (if at all) to purchase plants from an accredited source, were a scheme to be introduced. This was recorded in interval-ratio format using sliding scales.

The survey was tested and revised through piloting with a consortium of plant health experts before being distributed through a specialist panel survey company. Responses were collected through the panel company's registered respondents in April 2017. Responses were reviewed and assessed in relation to pre-set census-derived quotas in an attempt to ensure a sample representative of the wider population in respect of gender, region, and age bracket. The panel company subsequently made efforts to stimulate responses from

demographics that had not reached their quota via further direct and automated email invitations.

2.2 | Data analysis

Statistical analysis was conducted in R (R Core Team, 2016). All Likert scale responses were ordered and categorical, but did not follow the rule of proportional odds. As such, the data were analyzed using multinomial logistic regression in R (`multinom()` in the `nnet()` package, Venables & Ripley, 2002).

To test for differences by demographics, age, sex, and region were included as predictors within each model. Interactions were allowed between age, sex, and region, with non-significant interactions and main effects being removed from the final model. Source of plant purchases were separately tested for significant effects, with each option included within the model as a main effect.

For annual spend, initial analysis indicated these data were highly skewed, so spend was log₁₀ transformed to normalize the data, and subsequently applied as a continuous variable in a separate multinomial logistic regression model.

The significance of treatments and interactions (where applicable) were determined based on the likelihood-ratio chi-square test statistics from the analysis of deviance (Fox & Weisberg, 2011). Post hoc tests were used to estimate differences between categories, correcting for multiple comparisons using Bonferroni's multiple comparisons test. This provided the proportion of individuals partitioned into the four response categories for each factor/variable, significant difference lettering, and confidence intervals.

Having tested for significant differences between all categories and variables, the responses were subsequently divided into binary responses, with very aware and some awareness (or equivalent categories) being assigned a 1 and not at all aware and heard of but no knowledge being assigned a zero. Generalized linear models (probit link with binomial errors) were applied to the data, and the significance of treatments and interactions (where applicable) were determined based on the likelihood-ratio chi-square test statistics from the analysis of deviance (Fox & Weisberg, 2011). Post hoc tests were used to estimate differences between categories, correcting for multiple comparisons using Bonferroni's multiple comparisons test. These provided the proportion of individuals within each factor or variable who had some knowledge/a lot of knowledge of each response, significant difference lettering, and confidence intervals.

Responses regarding the additional distances that individuals are willing to travel and premium paid for accredited plant products were analyzed, using a range of predictors in turn (awareness, source and annual spend). For Willingness to Travel (WTT) data, the responses were log₁₀ transformed to normalize the data. Linear regression/analysis of variance was applied to the data, with post hoc tests used to estimate differences between categories, correcting for multiple comparisons using Bonferroni's multiple comparisons test. For Willingness to Pay (WTP) data (% premium), the data were analyzed using generalized linear models

(logit link with quasibinomial errors to account for overdispersion), and the significance determined based on the likelihood-ratio chi-square test statistics with post hoc tests corrected for multiple comparisons using Bonferroni's multiple comparisons test.

3 | RESULTS

3.1 | Sample characteristics

A total of 1,500 people over the age of 18 completed the survey, of which 49% were female and 51% were male (Dataset S1). The percentage of respondents from each geographic region also closely matched the relative distribution in the 2011 UK census. Despite the invitation to participate being distributed to a representative sample of each age band, many of those in the younger age bands proved ineligible for the survey as they had not obtained outdoor plants in the last 5 years. As a result, our sample does not match the UK census data with respect to age brackets, simply because there appears to be a greater propensity for older generations to buy outdoor plants. Annual spend on plants by respondents ranged from £10 to £2,500, with a mean average of £100.65.

3.2 | Awareness of tree and plant pests and diseases

Awareness of the threats to the UK's trees and woodlands from newly introduced pests and diseases was found to be slightly higher than in comparable studies with the wider public (e.g., Fuller et al., 2016; Urquhart et al., 2017), with some 10% of plant buyers having never heard of this problem generally, and a further 62% reporting to have heard of the problem but knowing little about it. Awareness of specific tree pests and diseases varied; two-thirds of the sample

(66%) had at least some knowledge of Dutch elm disease, but only 37% had some knowledge of ash dieback, despite the substantial media attention of the latter in the years immediately preceding the survey. Fewer than 20% reported to have any knowledge of the other six pests and diseases featured.

We found no relationship between where consumers obtain plants and their awareness of pest and disease threats to UK trees and woodlands. For example, those who buy plants from a supermarket are no more or less likely to be aware of the threats posed by pests and diseases than those who grow their own plants or purchase from any other source. However, individuals with a greater annual spend on plants tended to have greater awareness of pest- and disease-related threats. The modeled responses for the multinomial analysis revealed significant differences in the proportion of those who had never heard of this issue and for those who reported being reasonably well informed about it (comparing those spending £10, £100 and £500 per annum), with individuals spending more per year being significantly less likely to be ignorant of the issue and significantly more likely to consider themselves reasonably well informed (although this cannot be said to be significant for those spending £500 per annum due to small sample sizes at this higher spend).

3.3 | Plant-buying habits and drivers

The public use a variety of sources to obtain plants (Figure 1). Chief among these is garden centres, with 81% of the sample reporting to have used this source to obtain plants. A number of other generalist sources offering a large variety of non-plant products, such as DIY/hardware stores (56%) and supermarkets (49%) are also popular plant sources for the public. A substantial percentage of consumers obtain plants from their own existing seed stocks

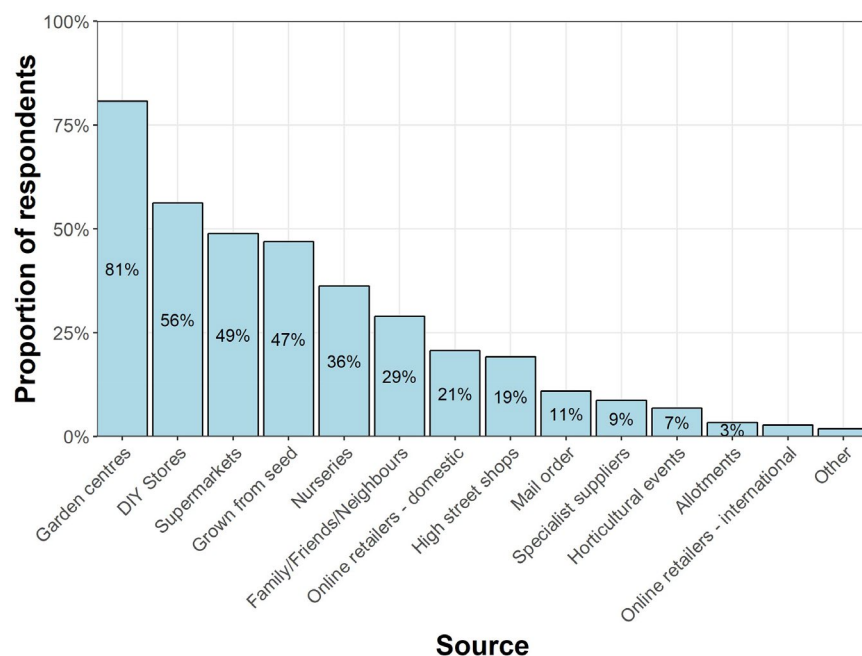


FIGURE 1 Use of various sources for obtaining plants by survey respondents

(47%), while 36% make use of nurseries. In terms of quantities of plants obtained, these five sources emerged as the most important yet again (ranking in the same order of importance). Frequency of obtaining plants from these five sources varied little, with between 52% and 66% of respondents obtaining only once or twice a year; between 23% and 35% obtaining three to five times per year; and between 7% and 15% obtaining six or more times per year. Some of the less utilized sources such as mail order and horticultural events elicited a different result—both being used significantly less frequently, with 78% and 88% using these respective sources just once or twice per year.

Quality of stock, cost, and range of plants emerged as the three most important factors when members of the public make a decision about where to obtain their plants (Figure 2). Of the 17 factors presented to participants, those with a perceptible link to plant health (cleanliness of premises, presence of biosecurity measures, and provenance of plants) ranked 6th, 10th, and 12th respectively. Similarly, when asked about factors influencing which individual plants are obtained, provenance ranked as the least important of the six options presented. In contrast, appearance, suitability for planting site, and cost proved to be the most important factors in this decision.

Friends, family, and neighbors emerged as the most commonly relied upon source for advice and guidance when buying plants (used by 50% of our sample). Other commonly relied upon sources include the internet and the advice of those selling the plants (used by 42% and 40% of the sample respectively). Media, gardening shows and events, national associations (e.g., the Royal Horticultural Society, Garden Organic, National Allotment Association, Federation of City Farms and Community Gardens), and local clubs/associations are comparatively unimportant sources of advice and guidance, with each relied upon by fewer than 17% of respondents.

3.4 | Importance of biosecurity measures among consumers

Modeled responses (Figure 3a) for multinomial analyses revealed significant differences by age group ($LR \chi^2 = 16.2, df = 20, N = 1,500$), with younger generations more likely to consider the clear presence of biosecurity measures as an important factor when deciding from which source to obtain their plants (Figure 3a). For example, 68% of 18- to 24-year-olds consider the presence of biosecurity measures as either important or very important, whereas the corresponding figure for the over 65-year-old demographic is only 33%. However, overall importance of biosecurity measures across the sample is skewed because of the greater propensity of older generations to buy plants; over 65-year-olds make up over one-third of the respondents (34%), while those from the 18- to 24-year-old bracket comprise less than 4%.

Those with a greater annual spend on plants are significantly more likely to view the presence of biosecurity measures as very important and important, while those spending less are significantly more likely to view the presence of the measures as unimportant or important (Figure 3b, $LR \chi^2 = 39.7, df = 4, N = 1,500$).

3.5 | Attitudes toward accreditation

To assess plant buyers' attitudes to accreditation we first explored their purchasing behaviour for a number of established accredited or certified products (Figure 4). For each type of product, a majority of the sample reported that they purchase the respective good at least some of the time (52%–72%). Some 38% of respondents stated that in some cases their decision to buy a (non-specific) accredited product was due to their belief in the ideals of accreditation

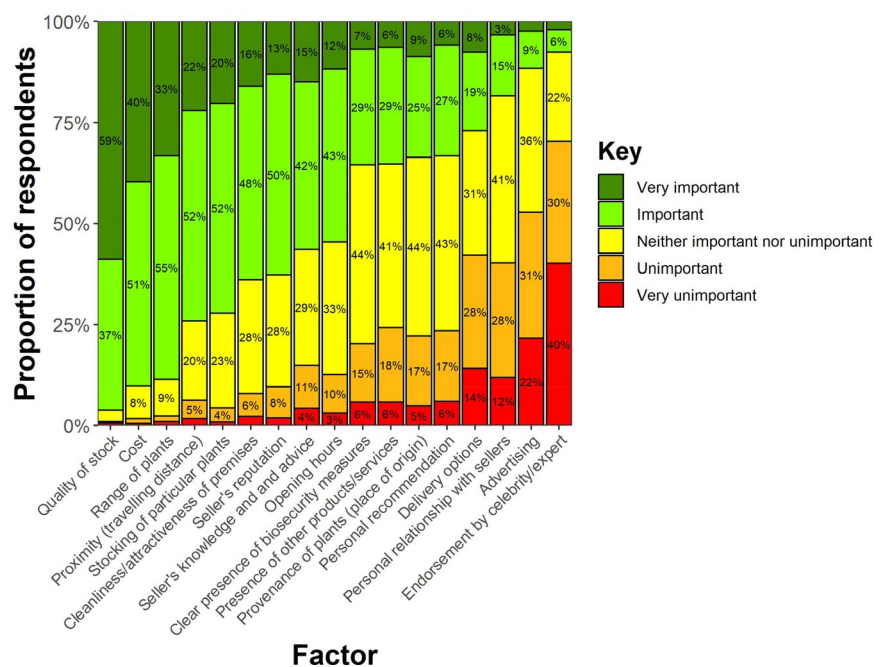


FIGURE 2 Importance ascribed to various factors by the survey respondents when deciding from where to obtain plants

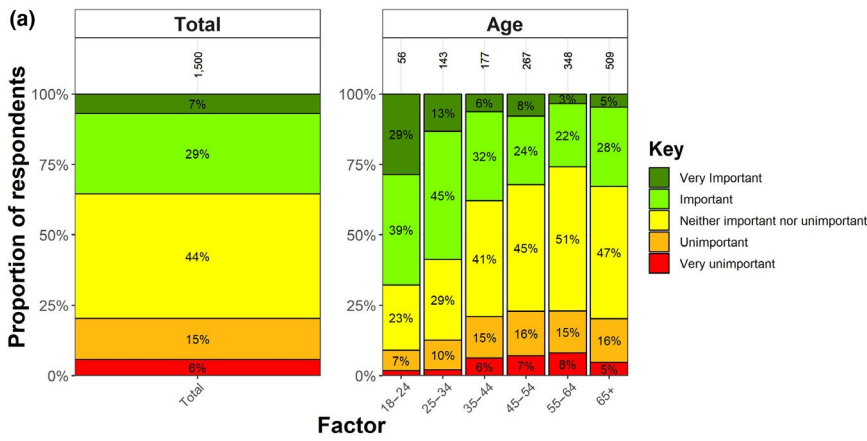


FIGURE 3 (a) Importance of the presence of biosecurity measures for plant buyers of different age; (b) violin plot of importance of biosecurity measures among plant buyers by annual spend on plants. Annual spend is presented on a log10 y axis to aid interpretation (predictor, not response). Red points indicate means

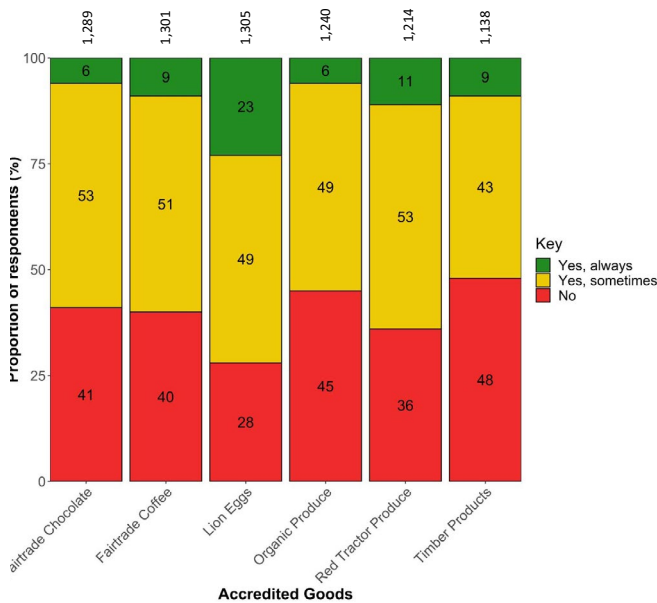
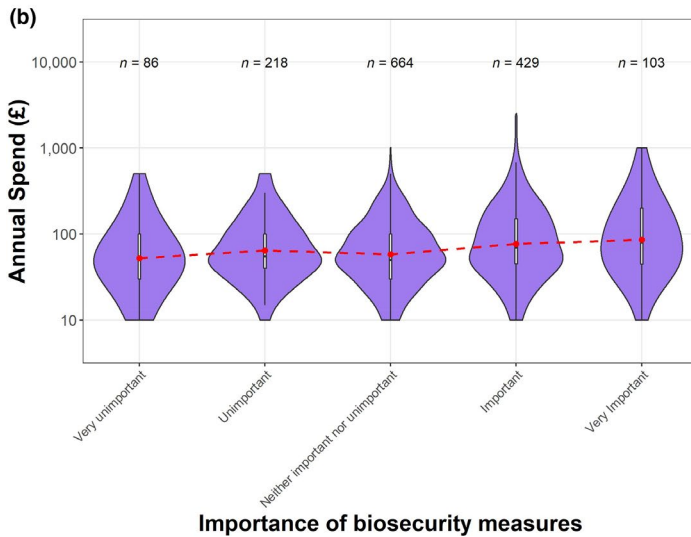


FIGURE 4 Existing purchasing behaviours of survey respondents with respect to various accredited products

schemes. However, 31% noted that they had at times decided to buy accredited goods because they perceived them to be of high quality. Relatively few responses were garnered in respect of decisions

to avoid accredited goods, with added expense being chief among these (only 9% of the sample). Despite this apparent support for accredited products, almost a third of the sample (32%) reported that they give little to no thought as to whether a product is accredited when making a purchase.

When asked about a hypothetical accreditation scheme for the nursery sector designed to safeguard the wider environment from the threat of pests and diseases, and help to ensure good quality as well as healthy plants for buyers, only 6% declared that they opposed the idea on the grounds that they felt the objectives would not be achieved. In contrast, 38% reported to be in favour of the scheme due to the intention to protect the wider environment, while a further 30% supported the idea owing to the likelihood that accredited plants would be of higher quality. A quarter of the sample noted that while they agreed with the ideals of the scheme they felt unable to express outright support owing to their concerns that associated costs would be passed on to them as the consumer.

Forty-five percent of the sample stated that they would be likely/very likely to travel further to obtain plants from an accredited source, with the greatest each-way distance reported being 160 miles and a mean each-way distance of 26 miles. As depicted in Figure 5, there was a significant ($F_{1,407} = 79.4, p < .0001$) linear increase in additional distances individuals were willing to travel (log10 miles) with increasing annual spend (log10 £). Post hoc tests

indicated that individuals spending £500 annually were willing to travel significantly further than those spending £100, and those spending £100 were willing to travel significantly further than those spending £10 (additional 36, 22, and 11 miles each way respectively).

Thirty-nine percent of respondents expressed a willingness to pay more for plants from an accredited source, with the greatest reported premium being 94% and a mean premium of 18%. There was a significant (LR $\chi^2 = 13.7$, $p < .001$) increase in the additional premium individuals who were willing to spend (%) with increasing annual spend (log₁₀ £). Post hoc tests indicated that individuals spending £500 annually were willing to pay a significantly greater premium than those spending £100, and those spending £100 were willing to pay a significantly greater premium than those spending £10 (additional 24%, 19%, and 13% respectively).

4 | DISCUSSION

Although particular attention has been placed on nurseries for their role in the introduction and spread of pests and diseases (Chavez et al., 2016; Ivors et al., 2006; Pautasso et al., 2010), our findings demonstrate that an accreditation scheme designed to reduce this threat must encompass a wide variety of sources if it is to reflect consumers' current buying habits. A single scheme encompassing multiple sources would be preferable (as opposed to multiple schemes for different types of growers and sellers), since this would limit confusion over the schemes' objectives and the relative merit of the public's purchasing decisions (Zaman, Miliutenko, & Nagapetan, 2010).

In the case of non-horticultural buying habits, a majority of the survey respondents report purchasing accredited products for at least on some occasions. Agreement with a scheme's ideals (e.g., sustainability) was often cited as the primary motivation for choosing to buy such products, though other studies suggest that this agreement does not always transcend to purchasing choices. For example, Schröder and McEachern's (2004) study into ethical meat purchasing demonstrated a value conflict among the Scottish public—as citizens, support was expressed for the notion of animals being entitled to a good life, whereas as meat consumers, the cognitive connection with the live animal was avoided. A similar scenario may result in the case of a plant health accreditation scheme; although the UK public have repeatedly expressed their appreciation for the wider environment, including treescapes (Fuller et al., 2016; Forestry Commission, 2017; Natural England, 2018), awareness of the threats pests and diseases pose to these environments is limited (Fuller et al., 2016; Urquhart et al., 2017). Furthermore, biosecurity—which would help to safeguard the wider environment (Brasier, 2008; Parke & Grünwald, 2012)—is generally unimportant in the public's decisions about which plants to obtain, and from which source. Thus, while the public are sympathetic to the aims of an accreditation scheme, there is a risk that the link between their purchasing choices and the safeguarding of the wider environment remains too intangible to facilitate the necessary behavioural change.

Those sources most heavily relied upon for plant purchasing (garden centres, supermarkets, DIY/hardware stores, and nurseries) are well-placed to raise public awareness about the threats posed to the wider environment by plant pests and diseases, the benefits of best biosecurity practices, and the merit of responsible consumer choices. This role could prove vital in the successful establishment of a scheme, with previous research highlighting that it is imperative consumers are clear and convinced about a scheme's aims and its viability (Eden, Bear, & Walker, 2008). However, some actors may have reservations about how their role in conveying downbeat messages would affect their business. Moreover, there is a need to further explore the sector's receptiveness to an accreditation scheme and the constituent biosecurity practices it would require.

Until such time that the link between sound biosecurity and safeguarding of the wider environment becomes more tangible for consumers, accreditation is likely to be most attractive when the primary emphasis is on quality assurance (i.e., offering healthy plants which are less likely to succumb to infection post-purchase). Our findings demonstrate that consumers already consider quality of stock to be the most important driver when deciding where to obtain plants, echoing Safley and Wohlgenant's (1995) findings that plant quality is the key factor with respect to which garden centre consumers choose to buy from. It is also likely that the public's current assessment of plant quality (and health) is based on a visual inspection, reflecting the importance ascribed to appearance when selecting the kind of plants to buy. Although a visual inspection undoubtedly has some value, it remains a somewhat limited practice since asymptomatic plants may not reflect the absence of pathogens (Oudemans, Hillman, Linder-Basso, & Polashock, 2011; Polston, McGovern, & Brown, 1999), and the use of chemical treatments may suppress or belie infections which only transpire post-purchase (Daughtrey & Benson, 2005; Rechcigl, 2003). Therefore, an accreditation scheme offering consumers assurance about the quality of products being purchased is likely to be highly valued. In the case of non-horticultural accredited products, perceptions of higher quality are responsible for their selection over non-accredited varieties by over 30% of buyers, with a similar figure expressing their support for a hypothetical accreditation scheme in the horticultural sector on the grounds that it would lead to higher quality plants being offered. All of these findings point to the importance of emphasizing quality assurance when establishing and promoting a plant health accreditation scheme.

Although the promise of high quality, healthy plants, and protection of the wider environment could engender public support for a plant health accreditation scheme, our study (and Urquhart et al., 2017) indicates that increased costs could hamper this support. Joshi and Rahman (2015) similarly highlight the importance of cost for achieving public support by citing 10 studies in which higher prices outweighed ethical considerations in the case of "green product" purchases. Concerns about increased costs resulting from the purchase of plants from accredited horticultural businesses are not unreasonable, since it is entirely feasible that growers and sellers will experience rising expenditure as a result of biosecurity investment

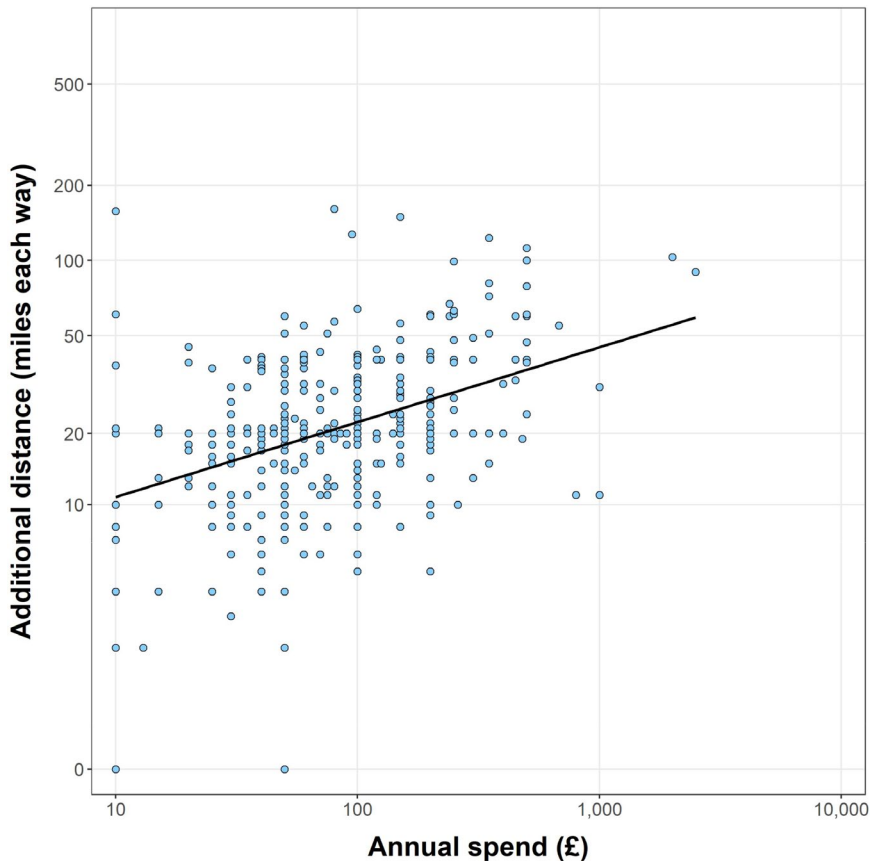


FIGURE 5 Survey respondent's Willingness to Travel (WTT) for accredited plant products against individual's annual spend on plants

and maintenance (Breukers, Asseldonk, Bremmer, & Beekman, 2012). Other potential costs for accredited businesses could include scheme membership fees, administration and inspection costs, and perhaps even penalties for poor performance. As growers and sellers seek to remain profitable, they may be forced to raise the prices of their goods. This could result in consumers opting to buy from non-accredited sources offering cheap and readily available plants in the absence of costs and restrictions associated with accreditation and best biosecurity practice. If this were to be the case, the impact of the accreditation scheme would be severely reduced.

While there is likely to be a degree of trepidation within the sector as to whether costs associated with biosecurity improvements and membership of a scheme would prove a worthwhile undertaking from an economic perspective (Brasier, 2008; Counsell & Loraas, 2002), these costs may be perceived as an investment or insurance policy against potential losses of stock and cessation of operations (which occurs when a regulated pest or disease is found on the premises). Growers and sellers may also take some solace from consumers' existing use of accreditation schemes, as well as previous research demonstrating a positive association between businesses inclined toward corporate social responsibility and perceived quality of their products (Murray & Vogel, 1997). Our findings show that 39% percent of plant buyers expressed a willingness to pay more for plants from an accredited source (mean premium 18%). It is also noteworthy that those plant buyers who spend most tend to view the presence of biosecurity measures as being more important than those who spend less, suggesting that they are the consumers who

will perceive an accreditation scheme underpinned by best biosecurity practice to be of greatest value. This is likely a result of higher spending consumers having most to lose from pest and disease infested stock, since they acquire comparatively expensive and/or large volumes of trees and plants. In addition, almost half of the sample (45%) expressed a willingness to travel further to buy accredited plants, signifying a potential opportunity for a scheme's early adopters to attract new clientele from further afield. The tendency for the biggest spenders to travel greater distances for accredited plants indicates that a business' accredited status could help to attract not only new, but also high value consumers. Further research is required to establish whether this tendency applies to commercial consumers (such as landscapers and local authorities) and intermediary consumers (such as DIY/hardware stores and garden centres) whose spends are far larger than the average member of the general public.

While our findings indicate that there may be market benefits for the early adopters of a scheme, meaningful impact in terms of safeguarding the wider environment from pests and diseases will depend on more widespread support from both the sector's businesses and consumers. Given that one-third of our sample indicated they give little or no thought about accredited status when deciding which products to purchase, a scheme's success may ultimately depend on establishing a degree of market saturation at which consumer choice is largely restricted to accredited products. For example, a near ubiquitous scheme such as the British Lion food safety scheme—through which around 95% of the UK's eggs are produced—can achieve its

objective of reducing salmonella poisoning in spite of any consumer apathy or obliviousness (Murchie et al., 2007; O'Brien, 2012). Were a plant health accreditation scheme to achieve similar ubiquity the use of accredited plant products would be substantially increased. Ultimately this would serve to mitigate the threats pests and diseases pose to horticultural businesses and the wider environment. However, further research is required to establish if widespread uptake of a scheme could be achieved purely through voluntary uptake—as in the case of the Horticultural Trade Association's Plant Healthy initiative—or whether a compulsory approach would be required.

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AUTHOR CONTRIBUTIONS

Mike Dunn led on the design of the survey and oversaw collection of the data. He also wrote the manuscript with the exception of the data analysis section. Mariella Marzano provided input on the survey design and assisted in framing the article. She sourced much of the cited literature and also reviewed several early drafts of the article. Jack Forster led the data analysis and helped to interpret the data. He also wrote the data analysis section of the article.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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