# Estimating Consumer Integrated Pest Management (IPM) Knowledge

Andrew H. Jeffers[1], Bridget K. Behe[2], Michael Vassalos[3], William C. Bridges[4], and Sarah A. White[5]

Keywords. consumer, Delphi method, integrated pest management

Abstract. **Landscape pest management is challenging and has historically relied on traditional pesticide rotations. Integrated pest management (IPM) is a combination of chemical and nonchemical control methods to reduce pesticide usage and reliance. Scant literature is available on consumer knowledge of IPM. To address this gap in knowledge, 1000 respondents were surveyed to evaluate their understanding of IPM. Questions were vetted using the Delphi method with nine industry and academic experts. More than 75% of respondents had some knowledge or were very knowledgeable of IPM. More education contributed strongly to more knowledge of IPM. The results of this study are comparable to those of another study and show that consumers are more knowledgeable than horticultural professionals may realize. Horticultural professionals could capitalize on this potential new market, with the understanding that some consumers would still need guidance to understand the myriad components of an IPM program. Future studies should evaluate consumer willingness to pay for plant products grown using IPM techniques such as biological controls and reduced chemical–pesticide inputs and, specifically, whether consumers are willing to pay for such biological control products or landscape scouting services. Future studies should also examine an IPM certification of ornamental plants and how they might perform compared to traditionally grown plants or certified organic-grown plants.**

Landscape pest management has historically relied on rotating traditional pesticide chemistries for pest management. Nevertheless, this approach potentially results in environmental issues and health concerns (Harris et al. 2001; Koch et al. 2017). Furthermore, sole reliance on traditional chemical pesticide rotations can lead to potential resistance issues (Deguine et al. 2021; Jeffers and Chong 2021; Muniz-Junior et al. 2023; van der Sluijs et al. 2013; Whitehorn et al. 2012). Consequently, consumers (either individuals or companies/institutions) started exploring alternative pest control options, especially over the last two decades (Jeffers et al. 2023; Marshall et al. 2015).

The adoption of integrated pest management (IPM), which is a scientifically based, multifaceted approach to maintaining pest populations below damaging levels, is a strategy that helps reduce the potential for development of pesticide resistance, keeps pest populations at acceptable levels in the long term, and reduces negative environmental impacts (Dara 2019; Deguine et al. 2021). Part of the success of IPM is its capacity to mitigate pesticide resistance via blending nonchemical control methods with pesticide chemistries, which include mechanical/physical controls (physical removal, traps, etc.), cultural controls (sanitation, irrigation management, fertility management, proper plant placement, etc.), and biological controls (releasing/attracting beneficial organisms to manage pests) (Burkman and Gardiner 2014; Doehler et al. 2023; Jeffers and Chong 2021; Wilson and Frank 2023). Biological control release programs have become more prevalent in production horticulture in the last 20 years (Messelink and Janssen 2014; Pandit et al. 2022; Smagghe et al. 2023), primarily because of environmental concerns regarding pesticides, specifically, pollinator risk with neonicotinoid insecticides. One challenge with successful biological control programs is their reliance on robust and accurate scouting programs (Jeffers and Chong 2021).

The successful widespread adoption of IPM for landscape management depends on several issues. Two facets of adoption include the complexity of the solution and the potential knowledge among consumers of what IPM is (Dara 2019; Diaz et al. 2020). Although previous research has examined some of these issues, limited literature about consumer knowledge of IPM is available (Kelley and Wehry 2006; Kelley et al. 2006; Sellmer et al. 2003, 2004). Jeffers et al. (2023) evaluated consumer self-reported knowledge of IPM; however, the study was designed using a single, self-stated Likert scale question regarding IPM knowledge without validation of actual knowledge.

The objective of this study was to evaluate actual and self-stated consumer knowledge of IPM. Characterizing consumer knowledge of IPM will provide landscape professionals with marketing information for pest management treatment plans, specifically regarding more holistic treatment options. This information could also be used to develop new marketing strategies for nursery and greenhouse growers who cannot grow US Department of Agriculture–certified organic plants because it is not economically feasible but can produce plants using sustainable IPM practices.

## Materials and methods

**Survey development.** The Delphi technique was developed in the 1950s and is used to attain a consensus on various issues and topics from industry and academic experts (Habibi et al. 2014; Haynes et al. 2024; Lamm et al. 2021; Raudales et al. 2014; Turoff and Linstone 2002). The Delphi technique usually involves a series (rounds) of questionnaires given to a panel of private sector and academic experts. The process starts with open-ended

Received for publication 5 Dec 2024. Accepted for publication 8 Jan 2025.

Published online 3 Mar 2025.

[1]Clemson University Cooperative Extension, 352 Halton Road Suite 302., Greenville, SC 29607, USA

[2]Michigan State University, Department of Horticulture, 1066 Bogue Street, Room A238, East Lansing, MI 48824, USA

[3]Clemson University, Department of Agricultural Sciences, 233 McAdams Hall, 821 McMillan Road, Clemson, SC 29631, USA

[4]Clemson University, Department of Mathematical Sciences, O-114 Martin Hall, 220 Parkway Drive, Clemson, SC 29634, USA

[5]Clemson University, Department of Plant and Environmental Sciences, 167 P&A Building, Clemson, SC 29634, USA

S.A.W. is the corresponding author. E-mail: swhite4@clemson.edu.



https://doi.org/10.21273/HORTTECH05586-24

questions. The panel rates answers from the first round in two subsequent rounds or until a consensus is met, producing more compressive results (Habibi et al. 2014; Haynes et al. 2024; Lamm et al. 2021; Raudales et al. 2014; Turoff and Linstone 2002). In horticulture, the technique has been used to identify critical issues for the horticulture industry during the COVID-19 pandemic (Lamm et al. 2021). The technique can also be used to develop questionnaires, programs, and curricula (Haynes et al. 2024).

To evaluate respondent IPM knowledge, a set of questions was developed to test participant knowledge of IPM (Supplemental Material). A panel of nine academic experts was selected to evaluate a set of 20 questions that were chosen to test respondents' knowledge of IPM. The initial Delphi round asked the panel if the questions were valid, had more than one answer, or if the question needed to be changed (Habibi et al. 2014; Lamm et al. 2021; Raudales et al. 2014; Turoff and Linstone 2002). The panel was also asked what questions should be included in the questionnaire. In the second round, the edited questionnaire was sent back to the panel to be evaluated a second time. The process yielded 12 questions to be administered to participants in the final survey.

Questions were then graded and grouped based on the percentage of questions that survey participants answered correctly. Participants who scored 45% or lower were classified as "not knowledgeable of IPM" because they answered more than half of the questions incorrectly. Those with scores between 45% and 75% were classified as "somewhat knowledgeable." Those with scores higher than 75% were classified as "very knowledgeable." Group categories were based on the self-stated Likert scale groups of Jeffers et al. (2023).

Cross-tabulations were performed using SPPS software (SPSS for Windows, version 16.0; SPSS Inc., Chicago, IL, USA) to compare respondent IPM knowledge to demographic classifications. Chi-square association tests were performed to determine the association between IPM knowledge and respondent demographic categories. An ordinary least squares regression analysis was performed to determine which, respondents' demographic characteristics contributing to their scores on the IPM questionnaire. The IPM score was the dependent variable and demographic characteristics were the independent variables.

The survey and protocol were approved (IRB no. 2022-0415) and distributed to respondents in the United States through Qualtrics Panel Services (Qualtrics LLC, Provo, UT, USA). Respondents qualified for the study if they were 18 years of age or older and if they had a lawn/landscape service at the time of the survey. The second section of the survey instrument collected demographic data, including the number of adults and children in the household, age (at the time of the survey), gender, race, education level, state of residence, region, and self-reported income level.

## Results and discussion

**Measurement of IPM knowledge.** A total of 1000 respondents completed the survey. Sixty-four percent of respondents were female. Nearly 52% of respondents reported living in a suburban area. The average number of adults in the household of the sample was 2.22, with an average of 0.71 children per household. Fifty-two percent of respondents reported an annual household income between $40,000

**Table 1. Summary of demographics of respondent to the integrated pest management knowledge survey ($n$ = 1000).**

| Variable | Mean | Median | % of total | *SE* |
|---|---|---|---|---|
| Adults in household | 2.22 | 2.00 | — | 0.06 |
| Children in household | 0.71 | 0.0 | — | 0.04 |
| Home type | | | | |
| Multifamily home | — | — | 26.8% | — |
| Single-family home | — | — | 97.3% | — |
| Income | | | | |
| <$9,999 | — | — | 4.40% | — |
| $10,000–$39,999 | — | — | 24.1% | — |
| $40,000–$69,999 | — | — | 32.7% | — |
| $70,000–$99,999 | — | — | 19.6% | — |
| $100,000–$149,999 | — | — | 12.0% | — |
| >$150,000 | — | — | 7.20% | — |
| Years of education | | | | |
| <12 years | — | — | 6.30% | — |
| 12 years | — | — | 25.9% | — |
| 14 years | — | — | 23.3% | — |
| 16 years | — | — | 25.9% | — |
| 18 years | — | — | 10.4% | — |
| Gender | | | | |
| Male | — | — | 35.1% | — |
| Female | — | — | 64.1% | — |
| Other | — | — | 0.30% | — |
| Prefer not to answer | — | — | 0.50% | — |
| Area of residence | | | | |
| Rural | — | — | 23.6% | — |
| Suburban | — | — | 51.7% | — |
| Urban | — | — | 24.7% | — |
| Gardening hours per week | 7.1 | 4.0 | — | 0.29 |
| US Department of Agriculture region | | | | |
| Delta | — | — | 3.0% | — |
| Eastern Mountain | — | — | 13.0% | — |
| Great Lakes | — | — | 11.0% | — |
| Heartland | — | — | 6.0% | — |
| Mountain | — | — | 7.0% | — |
| Northeastern | — | — | 19.0% | — |
| Northern Plains | — | — | 2.0% | — |
| Northwest | — | — | 3.0% | — |
| Pacific | — | — | 12.0% | — |
| Southern | — | — | 14.0% | — |
| Southern Plains | — | — | 8.0% | — |
| Upper Midwest | — | — | 3.0% | — |

*SE* = standard error.

**Table 2. Summary of integrated pest management (IPM)-based information collected from respondents to the IPM knowledge survey ($n$ = 1000).**

| Variable | Mean | Median | % of total | *SE* |
|---|---|---|---|---|
| Landscape service provider: environmental concern importance[i] | | | | |
| Not very important | — | — | 2.80% | — |
| Somewhat not important | — | — | 2.00% | — |
| Neither important nor not important | — | — | 14.8% | — |
| Somewhat important | — | — | 34.9% | — |
| Very important | — | — | 45.5% | — |
| Landscape service provider: nonchemical preference[ii] | | | | |
| Very unlikely | — | — | 4.90% | — |
| Somewhat unlikely | — | — | 7.60% | — |
| Somewhat likely | — | — | 51.7% | — |
| Very likely | — | — | 35.8% | — |
| Self-stated IPM knowledge[iii] | | | | |
| No knowledge | — | — | 42.0% | — |
| Some knowledge | — | — | 41.9% | — |
| Very knowledgeable | — | — | 16.2% | — |
| Tested IPM knowledge | | | | |
| IPM score | 58.2% | 58.0% | — | 0.01 |
| No knowledge | — | — | 25.2% | — |
| Some knowledge | — | — | 62.4% | — |
| Very knowledgeable | — | — | 12.4% | — |
| Purchase biocontrol[iv] | | | | |
| No | — | — | 21.5% | |
| Yes | — | — | 78.6% | — |

[i] How important is the landscaper's commitment to water and environmental protections to your decision to use that service?

[ii] If a landscape/lawn service provider offered nonchemical control options in combination with pesticide use to manage pests in your yard, how likely would you be to purchase their services?

[iii] How aware are you of integrated pest management (IPM)—the combination of chemical and nonchemical methods in a comprehensive management plan—to manage pests and keep them at acceptable levels?

[iv] If a landscape contractor offered you a nonchemical method such as releasing beneficial insects as a preventative measure, would you prefer this approach instead of chemical pesticides?

*SE* = standard error.

and $99,999. Nearly 60% of respondents had at least 14 years of education (Table 1).

Forty-two percent of respondents indicated they had "no knowledge" of IPM, while 41% indicated they had "some knowledge." Only 16% indicated they were "very knowledgeable" about IPM. The average score of the IPM knowledge questionnaire was 58%, which was part of the "some knowledge" of IPM category (Table 2). Results from the tested knowledge portion revealed that the actual knowledge of the respondents was better than their self-identified knowledge. A total of 62.4% of respondents answered enough questions correctly to indicate they had "some knowledge" of IPM, and 12% of respondents were "very knowledgeable"; however, 25% of respondents who answered less than half of the questions correctly were considered to have "no knowledge" of IPM (Table 2). The distributions of respondents within score groups were consistent with knowledge groups in a previous self-reported IPM knowledge and practice study (Diaz et al. 2020).

Cross-tabulation comparison results indicated that respondents with higher income levels and years of education were more knowledgeable about IPM (Table 3). Results from cross-tabulations showed a similar trend of respondents' IPM knowledge being normally distributed, with the majority of respondents by demographic having "some knowledge" of IPM (Table 3). Chi-square tests of association were performed to determine the association between IPM knowledge and respondent demographic categories. Years of education, income level, and gender were highly associated with respondent IPM knowledge ($P < 0.0001$, $P = 0.001$, and $P = < 0.05$, respectively) (Tables 2 and 3). Survey respondents with 16 years of education or more were more knowledgeable of IPM (Tables 2 and 3). Compared with the baseline of 12 years of education, respondents with 16, 18, or ≥20 years of education were likely to be more knowledgeable of IPM ($P < 0.001$, $< 0.05$, and $< 0.01$, respectively), consistent with those reported by Jeffers et al. (2023) (Table 4). Respondents with reported income of $9999 or less had less IPM knowledge ($P < 0.001$) (Tables 4 and 5). Area of residence (i.e., rural, suburban, or urban) did not impact knowledge of IPM (Tables 4 and 5). Male respondents were more likely than female respondents to be knowledgeable of IPM ($P = 0.039$) (Table 4).

Because higher education and higher income levels are often highly correlated, landscape service providers can use this information to offer alternative control treatments such as biological control agent releases to manage pests of clients. The results of this study are more promising than those of Jeffers et al. (2023) because, although a majority of respondents were in the "some knowledge" range, they provide horticultural professionals with a starting point to build or tailor pest management programs to meet specific client needs. Furthermore, they could possibly enable new business opportunities for nonchemical treatment management options for landscapes that could potentially bring higher profit margins and reduce the overall environmental impact with the reduction in pesticide use. Jeffers et al. (2023) reported that consumer IPM knowledge influenced the likelihood of purchasing a scouting program offered by a landscape professional, with those with more self-reported knowledge being more willing to consider purchasing a scouting program. If consumers are more knowledgeable than professionals perceive, then there may be opportunities for professionals to capitalize on new markets such as certified IPM-grown plants or IPM-related services such as biological control. In fact, nearly 79% of respondents in this survey indicated they would purchase a biological control program offered by a landscaper, which is a hallmark of IPM programs (Burkman and Gardiner 2014; Doehler et al. 2023; Jeffers and Chong 2021; Wilson and Frank 2023).

**Table 3. Survey respondents' integrated pest management (IPM) knowledge cross-tabulated with demographic information.**

| Demographic | Current study ($n$ = 1000) | | |
|---|---|---|---|
| | Little to no knowledge | Some knowledge | Very knowledgeable |
| Income level | | | |
| <$9,999 | 10.0% | 2.9% | 0.8% |
| $10,000–$39,999 | 22.9% | 24.1% | 25.0% |
| $40,000–$69,999 | 32.5% | 33.3% | 29.8% |
| $70,000–$99,999 | 17.7% | 19.1% | 27.4% |
| $100,000–$149,000 | 10.4% | 12.8% | 11.3% |
| >$150,000 | 6.4% | 7.9% | 5.6% |
| Years of education | | | |
| <12 years | 10.8% | 4.8% | 4.8% |
| 12 years | 32.5% | 25.2% | 16.1% |
| 14 years | 22.5% | 23.9% | 21.0% |
| 16 years | 18.9% | 27.1% | 33.1% |
| 18 years | 9.6% | 10.3% | 12.9% |
| ≥20 years | 5.6% | 8.6% | 12.1% |
| US Department of Agriculture region | | | |
| Delta | 2.4% | 3.4% | 0.8% |
| Eastern Mountain | 12.9% | 12.8% | 12.1% |
| Great Lakes | 11.6% | 10.5% | 13.7% |
| Heartland | 6.0% | 5.5% | 4.8% |
| Mountain | 7.2% | 6.9% | 6.5% |
| Northeastern | 19.7% | 18.6% | 18.5% |
| Northern Plains | 1.6% | 2.3% | 2.4% |
| Northwest | 4.8% | 2.4% | 4.0% |
| Pacific | 9.6% | 13.1% | 10.5% |
| Southern | 15.3% | 13.7% | 16.9% |
| Southern Plains | 6.4% | 7.8% | 8.9% |
| Upper Midwest | 2.4% | 3.1% | 0.8% |
| Gender | | | |
| Female | 71.5% | 62.4% | 62.1% |
| Male | 28.5% | 37.6% | 37.9% |
| Area of residence | | | |
| Rural | 26.9% | 21.3% | 28.2% |
| Suburban | 51.0% | 52.5% | 50.0% |
| Urban | 22.1% | 26.2% | 21.8% |

More than 50% of respondents correctly answered the question about the technical definition of IPM. However, when examining responses to some of the more specific questions about IPM terminology, such as cultural controls or what defines chemical management, the results were more mixed. For example, respondents overwhelmingly answered specific questions using the terms "herbicide" and "pesticide" as "chemical management," but they seemed confused by horticultural oils being grouped with chemical management. Approximately 50% of respondents correctly answered that their yard cannot be totally pest-free. Respondents did correctly answer questions related to biological controls. Given the increase in producers of biological controls and advances in the field, this may be a potential new revenue stream for horticultural producers and landscape professionals who want to market nonchemical control treatments to their customers. Further studies are needed to determine how much consumers would be willing to pay for such services.

Much work still needs to be done in terms of educational outreach to consumers regarding IPM principles and applications. Although respondents tested well in terms of their knowledge of IPM, determining whether they use this knowledge in actual practice was challenging; this was a limitation to our study. A previous study that examined consumers' self-stated knowledge of IPM as well as measured their engagement in IPM tactics revealed that 55% of the respondents indicated that they manage pests with as few chemicals as possible; however, only 42% actually said they use nonchemical treatments (Diaz et al. 2020). Furthermore, only 49% said they accurately identified pests before treatment (Diaz et al. 2020). This gap between apparent knowledge and actions could be, in part, attributable to the time and effort required for IPM tactics. Most homeowners may not be willing to commit the time required to successfully implement IPM-based landscape management. Landscape service providers could strategically market IPM-related services, such as scouting or biological control applications, to clientele to help them implement environmentally sustainable practices.

Future studies should evaluate consumer willingness to pay a premium for plant products grown using IPM techniques such as biological controls and reduced pesticide inputs. Specifically, if consumers are willing to pay for biological control products or landscape scouting services, then they may be willing to pay more for plant materials grown using those same practices. In another study, 80% of respondents

**Table 4. Results of chi-square tests of associations between the respondents' demographics and survey responses and the relationship to integrated pest management knowledge.**

| Demographic | Current study ($n$ = 1000) | | |
|---|---|---|---|
| | Pearson $\chi^2$ | df | $P$ value |
| Income level | 31.417 | 10 | 0.001 |
| Years of education | 32.771 | 10 | <0.0001 |
| US Department of Agriculture region | 13.662 | 22 | 0.913 |
| Area of residence | 5.468 | 4 | 0.243 |
| Gender | 6.864 | 2 | <0.05 |

**Table 5. Regression analysis of respondent score on the integrated pest management (IPM) knowledge questionnaire with IPM score as the dependent variable ($n$ = 1000).**

| | IPM knowledge | |
|---|---|---|
| **Variable** | **Estimate** | ***SE*** |
| Constant | 0.559*** | 0.022 |
| Gender | | |
| Female | −0.019*** | 0.006 |
| Male[i] | | |
| Income | | |
| <$9,999 | −0.109** | 0.025 |
| $10,000–$39,999 | 0.024 | 0.013 |
| $40,000–$69,999 | 0.015 | 0.012 |
| $70,000–$99,999 | 0.036** | 0.058 |
| $100,000–$149,999 | 0.007 | 0.016 |
| Over $150,000[i] | | |
| Years of education | | |
| <12 years[i] | | |
| 12 years | −0.045*** | 0.012 |
| 14 years | 0.006 | 0.012 |
| 16 years | 0.036*** | 0.012 |
| 18 years | 0.022 | 0.017 |
| 20 years | 0.042* | 0.012 |
| Hours spent gardening | −0.001 | 0.001 |
| Area of residence | | |
| Rural | 0.002 | 0.009 |
| Suburban | −0.009 | 0.008 |
| Urban[i] | | |

[i] Base variable for each comparison within a category.
*, **, *** Significance at $P$ = 0.05, $P$ = 0.01, and $P$ = 0.001, respectively.
Residual deviation 336.97 on 977 df. AIC: 1776.1.
AIC = Akaike information criterion; df = degrees of freedom; *SE* = standard error.

indicated they would purchase a landscape scouting program (Jeffers et al. 2023). More than 80% of respondents in the current study correctly answered that scouting was an integral part of IPM. Horticultural professionals could capitalize on this potential new market, with the understanding that some consumers would still need guidance to understand the myriad components of an IPM program. Future studies should also evaluate the potential for "certified IPM-grown" ornamental plants and quantify consumer willingness to pay for plants grown using traditional, organic, or IPM practices.

## References cited


Burkman CE, Gardiner MM. 2014. Urban greenspace composition and landscape context influence natural enemy community composition and function. Biol Control. 75:58–67. https://doi.org/10.1016/j.biocontrol.2014.02.015.

Dara SK. 2019. The new integrated pest management paradigm for the modern age. J Integrated Pest Manage. 10(1). https://doi.org/10.1093/jipm/pmz010.

Deguine J-P, Aubertot J-N, Flor RJ, Lescourret F, Wyckhuys KAG, Ratnadass A. 2021. Integrated pest management: Good intentions, hard realities. A review. Agron Sustain Dev. 41(3). https://doi.org/10.1007/s13593-021-00689-w.

Diaz JM, Warner LA, Oi F, Gusto C. 2020. What do they know and what do they do? A national evaluation of landscape integrated pest management knowledge and use in the United States. J Integrated Pest Manage. 11(1):1–5. https://doi.org/10.1093/jipm/pmaa017.

Doehler M, Chauvin D, Le Ralec A, Vanespen É, Outreman Y. 2023. Effect of the landscape on insect pests and associated natural enemies in greenhouses crops: The strawberry study case. Insects. 14(3):302. https://doi.org/10.3390/insects14030302.

Habibi A, Sarafrazi A, Izadyar S. 2014. Delphi technique theoretical framework in qualitative research. Int J Eng Sci. 3(4):8–13.

Harris CA, Renfrew MJ, Woolridge MW. 2001. Assessing the risks of pesticide residues to consumers: Recent and future developments. Food Addit Contam. 18(12):1124–1129. https://doi.org/10.1080/02652030110050122.

Haynes CJ, Anderson R, Byrd AP, McCubbins OP. 2024. The CTE J. 12(1):1–19.

Jeffers AH, Behe BK, Vassalos M, Bridges WC, White SA. 2023. Consumer purchase likelihood of landscape management pest scouting program. HortTechnology. 33(6):493–498. https://doi.org/10.21273/HORTTECH05268-23.

Jeffers AH, Chong J. 2021. Biological control strategies in integrated pest management programs. Land-Grant Press by Clemson Extension. http://lgpress.clemson.edu/publication/biological-control-strategies-in-integrated-pest-management-programs.

Kelley KM, Conklin JR, Sellmer JC, Bates RM. 2006. Invasive plant species: Results of a consumer awareness, knowledge, and expectations survey conducted in Pennsylvania. J Environ Hortic. 24(1):53–58. https://doi.org/10.24266/0738-2898-24.1.53.

Kelley KM, Wehry RH. 2006. Consumer interest in gardening topics and preferred information sources. J Ext. 44(2):235–349. https://doi.org/10.3727/0734-4398-44.2.18.

Koch S, Epp A, Lohmann M, Bol G-F. 2017. Pesticide residues in food: attitudes, beliefs, and misconceptions among conventional and organic consumers. J Food Prot. 80(12):2083–2089. https://doi.org/10.4315/0362-028X.JFP-17-104.

Lamm K, Powell A, Lombardini L. 2021. Identifying critical issues in the horticulture industry: a Delphi analysis during the COVID-19 pandemic. Horticulturae. 7(11):416. https://doi.org/10.3390/horticulturae7110416.

Marshall S, Orr D, Bradley L, Moorman C. 2015. A review of organic lawn care practices and policies in North America and the implications of lawn plant diversity and insect pest management. HortTechnology. 25(4):437–446. https://doi.org/10.21273/HORTTECH.25.4.437.

Messelink GJ, Janssen A. 2014. Increased control of thrips and aphids in greenhouses with two species of generalist predatory bugs involved in intraguild predation. Biol Control. 79:1–7. https://doi.org/10.1016/j.biocontrol.2014.07.009.

Muniz-Junior G, Roque FO, Pires APF, Guariento RD. 2023. Are lower pesticide doses better? An evolutionary perspective on integrated pest management. Ecol Modell. 482:110408. https://doi.org/10.1016/j.ecolmodel.2023.110408.

Pandit MA, Kumar J, Gulati S, Bhandari N, Mehta P, Katyal R, Rawat CD, Mishra V, Kaur J. 2022. Major biological control

strategies for plant pathogens. Pathogens. 11(2):273. https://doi.org/10.3390/pathogens11020273.

Raudales RE, Irani TA, Hall CR, Fisher PR. 2014. Modified delphi survey on key attributes for selection of water-treatment technologies for horticulture irrigation. HortTechnology. 24(3):355–368. https://doi.org/10.21273/HORTTECH.24.3.355.

Sellmer JC, Kelley KM, Barton S, Suchanic DJ. 2003. Assessing consumer knowledge and use of landscape plant health care and integrated pest management practices through a computer-based interactive survey. HortTechnology. 13(3):556–561. https://doi.org/10.1007/s10340-019-01193-w.

Sellmer JC, Ostiugy N, Kelley KM, Hoover K. 2004. Assessing the integrated pest management practices of Pennsylvania, US. Landscape Companies. J Arboric. 30(4) https://doi.org/10.48044/jauf.2004.030.

Smagghe F, Spooner-Hart R, Chen Z-H, Donovan-Mak M. 2023. Biological control of arthropod pests in protected cropping by employing entomopathogens: Efficiency, production and safety. Biol Control. 186:105337. https://doi.org/10.1016/j.biocontrol.2023.105337.

Turoff M, Linstone H. 2002. The Delphi method: Techniques and applications. New Jersey Institute of Technology, Newark, NJ, USA.

van der Sluijs JP, Simon-Delso N, Goulson D, Maxim L, Bonmatin J-M, Belzunces LP. 2013. Neonicotinoids, bee disorders and the sustainability of pollinator services. Curr Opin Environ Sustainability. 5(3-4):293–305. https://doi.org/10.1016/j.cosust.2013.05.007.

Whitehorn PR, O'Connor S, Wackers FL, Goulson D. 2012. Neonicotinoid pesticide reduces bumble bee colony growth and queen production. Science. 336(6079):351–352. https://doi.org/10.1126/science.1215025.

Wilson CJ, Frank SD. 2023. Urban tree pests can support biological control services in landscape shrubs. BioControl. 68(4):375–386. https://doi.org/10.1007/s10526-023-10192-8.