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Abstract. A mail survey was conducted in 2000 to determine awareness and use of integrated pest management (IPM) practices by nurseries in Pennsylvania. Survey participants were randomly selected from the Pennsylvania Dept. of Agriculture, Bureau of Plant Industry, list of certified nurseries. Participants answered questions pertaining to awareness of common practices, frequency that IPM practices were employed, and specifics on monitoring and pest management decision-making processes. Responses were analyzed by Cluster Analysis (SPSS Inc., Chicago), which resulted in the formation of three distinct segments. The segments were labeled “IPM Savvy” (nursery managers who were more likely to employ IPM practices); “Part-time IPMers” (nursery managers who employed some IPM strategies and were interested in future adoption of IPM practices); and “Reluctant IPMers” (nursery managers who were least likely to employ IPM strategies). The “Part-time IPMers” and “Reluctant IPMers” segments represent a substantial part of the industry (51%), who continue to have concerns about the cost, efficacy, and implementation of IPM practices into their businesses. Overall, Pennsylvania growers are aware of IPM practices; however, maintaining permanent records of pests identified and pest management strategies employed remain low. Continued education is warranted to enhance pest monitoring skills and recordkeeping along with demonstrable evidence to the cost-effectiveness and marketing benefits that the implementation of IPM practices offer the nursery operators.

The ornamental nursery industry has been actively discussing and employing IPM strategies since the mid 1980s (Raupp, 1985; Rhoads, 1985). The impetus for using IPM in nurseries arose for several reasons: 1) public concerns over pesticide use and pesticide residues (Dela-haut and Koval, 1994); 2) evidence that employing IPM practices can reduce production expenses by reducing pesticide use and associated labor costs while still providing adequate pest management (Raupp and Cornell, 1988); and 3) realization that customers are reluctant to purchase plants that are visibly damaged or defoliated due to pest activities (Sadof et al., 1987). The success of an ornamental IPM program centers on monitoring pest problems and employing a combination of management tactics, such as biological, chemical, cultural, and mechanical tactics to keep pest populations below damaging levels.

Economic thresholds have been defined for many production agriculture crops through experimentation, based on whether treatment will improve crop quality or yield enough to result in increased revenue to cover the extra cost of treatment. Unfortunately, aesthetic rather than economic thresholds are the most common decision-making criteria used for treatment of ornamental plants. Aesthetic thresholds based on damage levels or pest populations on ornamental plants are subjective, depending on the attitudes and knowledge of people managing the landscape or purchasing landscape plants (Dreistadt, 1994; Nielsen, 1990). Sadof et al. (1987) reported that of 100 retail customers within the Washington, D.C., area, a majority perceived plants as undesirable if they were even slightly defoliated. Unfortunately, few aesthetic threshold levels have been developed for ornamental plants, leaving growers to define acceptable thresholds on a case-by-case basis or plant species-by-plant species, based on experience.

IPM has been a cornerstone of extension educational efforts with commercial nursery producers in Pennsylvania. IPM concepts and practices are disseminated to producers through numerous forums, including organized educational programs, newsletters, websites, volunteer research groups, and industry and regulatory agency publications (J.C. Sellmer, personal observation).

Pennsylvania ranked fourth in the United States in number of farms producing nursery and greenhouse crops in 1997 (Willits and Shields, 2001). The Pennsylvania nursery industry includes nursery growers and nursery stock dealers certified by the Pennsylvania Dept. of Agriculture. Nursery growers were defined as businesses engaged primarily in the propagation and growing of nursery stock. They included garden centers, greenhouse production operations, hobbyists, landscape contractors, landscape nurseries, mail order operations, and production nurseries. In 2000, the Pennsylvania Dept. of Agriculture listed 2,687 certified nurseries on over 39,480 acres and 22,062,195 square feet under glass (Pennsylvania Dept. of Agriculture, 2000). The largest concentration of growers was located in southeastern Pennsylvania, followed by the southwestern and south central regions of the state. In all cases, growers were concentrated around the major metropolitan areas of Philadelphia, Pittsburgh, and Harrisburg.

The most recent nursery pest management surveys conducted nationally and locally occurred in the 1980s, 1990s, and in 2000. A national IPM survey, with an 11.5% response rate, was conducted in 1993 and focused on IPM practices used by the industry, pest control concerns, pesticide usage, and frequency of application, annual chemical use by number of genera grown, and annual chemical use by nursery size (Higginbotham, 1993). State specific nursery pest management surveys have also been reported for North Carolina (J.C. Sellmer et al., 2000), New York (Lamboy, 2002), Wisconsin (Dela-haut and Koval, 1994), and in Pennsylvania in 1979 (Shetlar and Heller, 1984). The Hawaii survey was conducted to determine pesticide use, perception of pest problems, postharvest treatments employed, and to identify research and educational needs to develop tropical crops and cut crops produced and exported to the mainland. The New York survey was directed toward greenhouse growers in order to evaluate the implementation of greenhouse IPM among diverse-sized operations. The Wisconsin survey was conducted in tandem with the initiation of a nursery IPM extension education program. Pennsylvania’s survey focused on insecticide and miticide usage among nurseries.

In 2000, a survey of the Pennsylvania nursery industry was conducted to determine the understanding of IPM concepts and practices, and use of these practices. The main objectives of the survey were to determine awareness and use of IPM, and to identify the level of implementation and factors that influence adoption of IPM practices. The overarching goals of this survey were to identify gaps in present educational efforts and develop research and educational programs to expand and support the
adoption of IPM practices among Pennsylvania nursery growers.

Materials and Methods

A survey was developed in 1999 and mailed to 1800 nurseries randomly selected from the Pennsylvania Dept. of Agriculture, Bureau of Plant Industry 2000 certified nurseries mailing list. Adapted from the Dillman method (Dillman, 2000) a survey was first mailed in Feb. 2000. In Apr. 2000, the same survey recipients received another copy of the survey, followed by a reminder postcard several weeks later.

The 14-page survey consisted of eight sections and 41 questions that focused on general perceptions of IPM principles and implementation of IPM practices; general monitoring activities for insect, disease, and weed pests; control and plant health care practices employed; integrated pest management practices, including perceptions of what limits the use of IPM practices; informational and educational needs, and resources for pest management decision-making; and demographic information. The experiment was approved by the Office for Research Protections, the Pennsylvania State Univ., which oversees the use of human participants.

Data analysis. Cluster analysis (SPSS Inc.) was used to determine whether meaningful IPM practitioner segments could be created, based on participant’s answers to several questions. Cluster analysis has been used by researchers to define consumer segments related to their preferences for horticultural products, such as edible flowers (Kelley et al., 2001), geraniums (Behe et al., 1999), and perceived consumer plant knowledge (Hardy et al., 1999). Variables used for clustering were the nursery stock producers’ knowledge and implementation of IPM or cultural practices. Responses were then analyzed to determine the level of knowledge of the participants regarding IPM subject matter. This information will be used by researchers and extension personnel to help them adjust their educational focus on topics where nursery stock producers lack knowledge or implementation. By using K-Means, 2, 3, and 4 clusters were examined using eight cluster algorithms. After examining each cluster size, the three-cluster solution was selected to develop producer-practitioner segments because it provided the most detail among respondents based on IPM knowledge and implementation.

Results and Discussion

General. Of the 1800 nurseries receiving surveys, 360 completed them, resulting in a response rate of 20%. This exceeded the past benchmark response rate of 11% for direct mail surveys (Reed, 1999). Among the respondents, 65% reported attaining a degree beyond high school. Eighty-seven percent of the respondents were the owners or partners in the nursery, while the remainder were managers and employees (13%). Nearly all respondents were involved in both the pest management (99%) and IPM (91%) decisions at the nursery.

A majority (80%) of respondents reported gross sales for 1998 of less than $250,001. The respondents were evenly divided, with 51% reporting total production under 3.5 acres and 49% with greater than 3 acres. Regarding business activities, a majority (73%) reported being involved in a combination of nursery-related operations including nursery production, Christmas tree growing, landscape operations, and garden center sales, whereas 18% reported being strictly involved in production nursery activities. Fifty percent of the nurseries had been in business more than 11 years. More than half of the businesses reported employing more than two full-time, part-time, and seasonal employees.

The top 10 most frequently recognized IPM practices among respondents were monitoring (86%); selecting resistant plant varieties (80%); keeping records (80%); removing heavily infested nursery stock (79%); removing plant debris (79%); using alternative pesticides (77%); using insecticidal soaps, horticultural oils, or repellents (74%); isolating plants with pests (74%); using conventional pesticides (69%); and maintaining weed-free perimeters (67%). To further determine the frequency with which IPM practices are employed, respondents were asked to rate their use of IPM practices on a scale from never to routinely. A majority of the respondents (63%) reported routinely employing IPM strategies. Similar levels of awareness and implementation were reported in the 1993 national IPM survey (Higginbotham, 1993), where 86% of the nurseries were fully (18%) or partially (68%) employing IPM, suggesting that recognition and use of IPM practices remains high among nurseries in Pennsylvania.

Monitoring pests is a cornerstone concept of IPM. Ninety-nine percent of survey respondents reported monitoring for insects at least once a month, and 89% monitoring for diseases during the same period. Weeds were the least monitored with only 68% monitoring at least monthly. Although daily scouting may be labor intensive and costly to maintain, weekly or monthly monitoring of pest activities during the growing season may be attainable and fulfill the need for monitoring frequency in the mid-Atlantic region (Raupp and Cornell, 1988).

Another important facet of monitoring for pests is keeping permanent records of the pests identified and control practices employed over time. This allows IPM practitioners to identify pest trends and persistent pest problems, reduces diagnosis time in future years, and provides documentation of effective and ineffective pest management strategies when the pest reappears in the nursery. Unfortunately, only 25% of the respondents reported keeping permanent records of pests identified in the nursery. Overall, these results suggest that the respondents are aware of IPM practices; however, they are not equally employing all of the practices at their nursery.

Cluster analysis (SPSS Inc.) was used to determine whether meaningful IPM practitioner segments could be created, based on participant’s answers to several key questions regarding implementation of IPM practices, pest monitoring, and identification. Three distinct segments were identified “IPM Savvy,” “Part-time IPMer,” and “Reluctant IPMer” (Table 1). Each segment clearly defined what practices are currently used to monitor for insects/mites, diseases, and weeds, level of future interest, opinions about IPM, and perceived limitations of IPM practices.

Segment 1. Of the three segments, the largest group, labeled “IPM Savvy,” consisted of 176 participants or 49% of the respondents. These participants routinely implemented IPM strategies (86%); monitored for weeds once a week during the season (38%); and were more likely to always identify diseases (42%), insects or mites (70%), and weeds (55%) accurately, compared to the other two segments. The “IPM Savvy” group was more likely to identify the presence of beneficial insects, mites, and other organisms (42%) and consider the potential impact of pests on plant species and the number of plants affected (89%) before deciding to treat for insect or mite problems. When monitoring for plant diseases, this group was more likely to identify the specific disease (85%), relate the problem to current and forecasted environmental conditions (53%), determine disease severity (85%), and consider plant condition (78%) than the other two segments. Similarly, this segment was more likely to target persistent problem weeds (85%), target weed control based on a vulnerable point within the life cycle (48%), and evaluate weed source (48%). Because this group was more active when answering questions about monitoring for pests (95%), they were also more likely to employ techniques that would assist in the practice of IPM. The “IPM Savvy” group tended to select pesticides (66%) and use cultural practices (68%) that conserve beneficial insects as well as to control weeds (82%). In addition, this group used insecticidal soaps (37%), horticultural oils (42%), and natural products such as botanicals (29%) more often than the other two population segments.

Current monitoring practices also assisted the “IPM Savvy” group when deciding when to spray for insects/mites or disease organisms. Of this segment, 0% always sprayed, 2% often sprayed, and 20% and 23% sometimes sprayed for insects/mites or diseases on a calendar schedule. A much larger percentage, 78% and 75%, respectively, rarely sprayed for insects/mites and diseases, respectively, on a calendar schedule. A much larger percentage, 78% and 75%, respectively, rarely sprayed for insects/mites and diseases, respectively, on a calendar schedule. However, if the pest or problem was observed or notified, the “IPM Savvy” group agreed that IPM practices benefited their nursery by saving money (60%) and allowing labor to be used more efficiently (61%). In addition, these respondents were more likely than the other segments to believe IPM practices are beneficial to the environment (93%) and that there are effective alternatives to chemical pesticides for dealing with most pests (54%). The “IPM Savvy” group was more likely to consider obtaining information via technology-based resources, such as e-mail (67%) and the World Wide Web (62%), for pest information.

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Table 1. Description of three Pennsylvania nursery segments derived from cluster analysis based on participant’s responses (in %) to IPM and cultural practice variables.

<table>
<thead>
<tr>
<th>Variable</th>
<th>IPM Savvy</th>
<th>Part-time IPMer</th>
<th>Reluctant IPMer</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency with which IPM strategies are used in the nursery:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Routinely</td>
<td>86</td>
<td>68</td>
<td>7</td>
<td>1, 3</td>
</tr>
<tr>
<td>Sometimes</td>
<td>14</td>
<td>27</td>
<td>67</td>
<td>1, 3</td>
</tr>
<tr>
<td>Rarely</td>
<td>0</td>
<td>4</td>
<td>17</td>
<td>1, 3</td>
</tr>
<tr>
<td>Monitors for insects:</td>
<td>8</td>
<td>9</td>
<td>16</td>
<td>3</td>
</tr>
<tr>
<td>Monitors for weeds:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annually</td>
<td>7</td>
<td>13</td>
<td>2</td>
<td>2, 3</td>
</tr>
<tr>
<td>Occasionally</td>
<td>15</td>
<td>21</td>
<td>28</td>
<td>1, 3</td>
</tr>
<tr>
<td>Once a week during the season</td>
<td>38</td>
<td>26</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>Upon notification of a pest problem by the Pennsylvania Dept. of Agriculture inspectors</td>
<td>4</td>
<td>13</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Identities disease problems accurately:</td>
<td>42</td>
<td>31</td>
<td>5</td>
<td>1, 3</td>
</tr>
<tr>
<td>Identifies insect or mite problems accurately:</td>
<td>70</td>
<td>51</td>
<td>24</td>
<td>1, 3</td>
</tr>
<tr>
<td>Identifies weed problems accurately:</td>
<td>55</td>
<td>50</td>
<td>18</td>
<td>1, 3</td>
</tr>
<tr>
<td>Techniques used to monitor for insects or mites:</td>
<td>30</td>
<td>27</td>
<td>45</td>
<td>3</td>
</tr>
<tr>
<td>Identifies the specific insect or mite</td>
<td>88</td>
<td>87</td>
<td>73</td>
<td>3</td>
</tr>
<tr>
<td>Identifies the presence of beneficial insects, mites, and other organisms</td>
<td>42</td>
<td>25</td>
<td>23</td>
<td>1, 3</td>
</tr>
<tr>
<td>Relates insect or mite presence to current and forecasted environmental condition</td>
<td>40</td>
<td>52</td>
<td>23</td>
<td>2, 3</td>
</tr>
<tr>
<td>Relates insect or mite presence to condition of host plant</td>
<td>63</td>
<td>66</td>
<td>39</td>
<td>1, 3</td>
</tr>
<tr>
<td>Keeps permanent records of pest monitoring</td>
<td>28</td>
<td>32</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Considers the following when deciding to treat for insects or mites:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incidence (how many plants are affected)</td>
<td>89</td>
<td>75</td>
<td>76</td>
<td>1, 2</td>
</tr>
<tr>
<td>Time of year</td>
<td>60</td>
<td>67</td>
<td>40</td>
<td>2, 3</td>
</tr>
<tr>
<td>Phenological indicators (for example, growing degree days, leaf flush, or flowering of nearby plants)</td>
<td>30</td>
<td>38</td>
<td>14</td>
<td>2, 3</td>
</tr>
<tr>
<td>Uses preventative blanket sprays to treat for insects or mites</td>
<td>34</td>
<td>57</td>
<td>35</td>
<td>1, 2</td>
</tr>
<tr>
<td>When monitoring for plant diseases:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Identifies the specific disease</td>
<td>83</td>
<td>83</td>
<td>58</td>
<td>1, 3</td>
</tr>
<tr>
<td>Relates disease presence to current and forecasted environmental conditions</td>
<td>53</td>
<td>49</td>
<td>26</td>
<td>1, 3</td>
</tr>
<tr>
<td>Determines disease severity</td>
<td>85</td>
<td>81</td>
<td>63</td>
<td>1, 3</td>
</tr>
<tr>
<td>Considers plant condition</td>
<td>78</td>
<td>73</td>
<td>56</td>
<td>1, 3</td>
</tr>
<tr>
<td>Considers plant variety</td>
<td>69</td>
<td>71</td>
<td>45</td>
<td>1, 3</td>
</tr>
<tr>
<td>Considers the following when deciding to treat for a plant disease:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of year</td>
<td>65</td>
<td>69</td>
<td>47</td>
<td>3</td>
</tr>
<tr>
<td>Phenological indicators (for example, growing degree days, leaf flush, or flowering of nearby plants)</td>
<td>28</td>
<td>40</td>
<td>18</td>
<td>2, 3</td>
</tr>
<tr>
<td>Preventative blanket sprays</td>
<td>39</td>
<td>58</td>
<td>32</td>
<td>2, 3</td>
</tr>
<tr>
<td>Consider the following when deciding to treat for a plant disease:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nursery layout based on key pest and plants to reduce pest access to susceptible plants</td>
<td>35</td>
<td>44</td>
<td>15</td>
<td>2, 3</td>
</tr>
<tr>
<td>Monitors for pests</td>
<td>95</td>
<td>90</td>
<td>78</td>
<td>1, 3</td>
</tr>
<tr>
<td>Selects pesticides that conserve beneficials</td>
<td>66</td>
<td>56</td>
<td>41</td>
<td>1, 3</td>
</tr>
<tr>
<td>Uses cultural practices that conserve beneficials</td>
<td>68</td>
<td>44</td>
<td>38</td>
<td>1, 2, 3*</td>
</tr>
<tr>
<td>Uses cultural practices that reduce weeds</td>
<td>82</td>
<td>75</td>
<td>70</td>
<td>1*</td>
</tr>
<tr>
<td>In the future, would like to do more of the following:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Isolates plants with pest problems for treatment</td>
<td>57</td>
<td>57</td>
<td>41</td>
<td>3</td>
</tr>
<tr>
<td>Weeding maintenance programs</td>
<td>87</td>
<td>84</td>
<td>72</td>
<td>1, 2, 3*</td>
</tr>
<tr>
<td>Currently uses the following often:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticultural soap</td>
<td>37</td>
<td>25</td>
<td>28</td>
<td>1</td>
</tr>
<tr>
<td>Natural products (for example, botanicals)</td>
<td>42</td>
<td>36</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>Chemical pesticides</td>
<td>53</td>
<td>87</td>
<td>48</td>
<td>1, 2</td>
</tr>
<tr>
<td>In the future, would like to do more of the following:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Horticultural oils</td>
<td>26</td>
<td>27</td>
<td>17</td>
<td>3</td>
</tr>
<tr>
<td>Chemical pesticides</td>
<td>7</td>
<td>12</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

*Table continued on next page.*
and had used the web (40%) more often than the other two segments to obtain information. There was a relationship between this group’s use of technology and IPM practices and their education level. A greater percentage of the “IPM Savvy” group (71%) obtained at least an associate’s degree, compared to the other two groups.

Segment 2. The second largest segment of the nursery population accounted for 96 of the survey participants (27%); and was designated as the “Part-time IPMer” group. This segment used some IPM and cultural practices and indicated that they would like to utilize additional practices more often in the future. Fifty-two percent of this segment monitored for insects or mites by relating presence of the pest to current and forecasted environmental conditions, and 57% considered using preventive sprays to treat for these pests. “Part-time IPMers” used phenological indicators when deciding to treat for a plant disease (40%); they also considered nursery layout based on key pests and key plants to reduce a pest’s access to susceptible plants (44%). This segment used information such as incidence of weeds (78%), species of weeds found (68%), and time of year (80%) more often than the other two segments when deciding how to treat for weed problems.

Of the three segments, “Part-time IPMers” were the greatest overall users of chemical pesticides (87%). They were also the greatest users of preemergence herbicides to reduce overall weed pressure (76%), thus reducing unplanned and excessive postemergence herbicide use. “Part-time IPMers” were the most likely to always spray herbicides on a set schedule (15%) and diseases (19%) whether a pest or problem was seen or not.

Even with this high percentage of chemical usage, the “Part-time IPMers” had the greatest interest among the segments in employing IPM practices more often in the future. This seg-

<table>
<thead>
<tr>
<th>Table 1. Continued.</th>
<th>Nursery segment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>IPM Savvy</td>
</tr>
<tr>
<td>Currently uses the following often:</td>
<td></td>
</tr>
<tr>
<td>Identifies weeds</td>
<td>70</td>
</tr>
<tr>
<td>Evaluates weed severity</td>
<td>86</td>
</tr>
<tr>
<td>Targets persistent problem weeds</td>
<td>85</td>
</tr>
<tr>
<td>Targets weed control based on vulnerable point within life cycle</td>
<td>61</td>
</tr>
<tr>
<td>Evaluates weed source (non-crop areas or proper edge)</td>
<td>48</td>
</tr>
<tr>
<td>Uses preemergence herbicides to reduce overall weed pressure</td>
<td>45</td>
</tr>
<tr>
<td>Uses targeted direct spray herbicides or wipe-on applicators</td>
<td>56</td>
</tr>
<tr>
<td>Eradicates perennial weeds before replanting a field</td>
<td>46</td>
</tr>
<tr>
<td>In the future, would like to do more of the following:</td>
<td></td>
</tr>
<tr>
<td>Identifies weeds</td>
<td>17</td>
</tr>
<tr>
<td>Targets persistent problem weeds</td>
<td>25</td>
</tr>
<tr>
<td>Uses preemergence herbicides to reduce overall weed pressure</td>
<td>29</td>
</tr>
<tr>
<td>Uses targeted direct spray herbicides or wipe-on applicators</td>
<td>20</td>
</tr>
<tr>
<td>Information used in the decision to treat for weed problems:</td>
<td></td>
</tr>
<tr>
<td>Incidence of a weed (a weed is present)</td>
<td>69</td>
</tr>
<tr>
<td>Species of weed found</td>
<td>56</td>
</tr>
<tr>
<td>Time of year</td>
<td>62</td>
</tr>
<tr>
<td>Sprays for insects or mites on a set schedule, whether pest is seen or not:</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>0</td>
</tr>
<tr>
<td>Often</td>
<td>2</td>
</tr>
<tr>
<td>Sometimes</td>
<td>20</td>
</tr>
<tr>
<td>Rarely</td>
<td>78</td>
</tr>
<tr>
<td>Sprays for disease on a set schedule, whether a problem is seen or not:</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>0</td>
</tr>
<tr>
<td>Often</td>
<td>2</td>
</tr>
<tr>
<td>Sometimes</td>
<td>23</td>
</tr>
<tr>
<td>Rarely</td>
<td>75</td>
</tr>
<tr>
<td>Uses herbicides on a set schedule:</td>
<td></td>
</tr>
<tr>
<td>Always</td>
<td>9</td>
</tr>
<tr>
<td>Often</td>
<td>11</td>
</tr>
<tr>
<td>Rarely</td>
<td>60</td>
</tr>
<tr>
<td>The following are a limitation when using IPM:</td>
<td></td>
</tr>
<tr>
<td>Sufficient information about pest biology</td>
<td>57</td>
</tr>
<tr>
<td>Availability of alternatives to chemical pesticides</td>
<td>72</td>
</tr>
<tr>
<td>Effectiveness of cultural practices</td>
<td>67</td>
</tr>
<tr>
<td>Cost of using IPM</td>
<td>52</td>
</tr>
<tr>
<td>Customer response to IPM</td>
<td>31</td>
</tr>
<tr>
<td>Uncertainties about effectiveness of IPM practices</td>
<td>60</td>
</tr>
<tr>
<td>Time requirements</td>
<td>68</td>
</tr>
<tr>
<td>Plant pest regulations</td>
<td>59</td>
</tr>
<tr>
<td>Availability of damage threshold used for making pest management decisions</td>
<td>63</td>
</tr>
<tr>
<td>Agree with the following in regards to using IPM practices:</td>
<td></td>
</tr>
<tr>
<td>IPM practices would save the nursery money</td>
<td>60</td>
</tr>
<tr>
<td>IPM practices are beneficial to the environment</td>
<td>93</td>
</tr>
<tr>
<td>IPM practices allow labor to be used more efficiently at the nursery</td>
<td>61</td>
</tr>
<tr>
<td>There are alternatives to chemical pesticides that are as effective in dealing with most pests</td>
<td>54</td>
</tr>
<tr>
<td>Monitoring pest and reducing pesticide use is too costly to implement</td>
<td>7</td>
</tr>
<tr>
<td>Would be interested in IPM handout materials to help educate customers</td>
<td>62</td>
</tr>
<tr>
<td>Received a higher education degree (associate degree or higher)</td>
<td>71</td>
</tr>
<tr>
<td>Participant makes the pest management decisions for the nursery</td>
<td>99</td>
</tr>
<tr>
<td>Two or more employees were full time in 1998</td>
<td>60</td>
</tr>
<tr>
<td>Three of more employees were seasonal in 1998</td>
<td>55</td>
</tr>
</tbody>
</table>

71 = Part-time IPMers and Reluctant IPMers combined and tested against 1; 2 = IPM Savvy and Reluctant IPMers combined and tested against 2; 3 = IPM Savvy and Part-time IPMers combined and tested against 3; 1, 2, 3 = all cluster comparisons are significantly different.

*NS = Nonsignificant or significant at P = 0.05, as based on a two-tailed t test and Kruskal-Wallis test.

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The third segment, designated "Reluctant IPMers" was least likely to have attained a college degree. Finally, nurseries in this segment employed fewer full time and seasonal employees in 1998 than the other two segments.

Trends among segments. The IPM segments revealed important differences in understanding, implementation, perceived limitations, and future interest in applying IPM strategies between the segments. Segment comparisons also identified similarities among IPM groups.

Few of the respondents employed growing degree days in their monitoring strategy for insects, diseases, or weeds although growing degree day and plant phenology guidelines have been developed for insect pest monitoring in Pennsylvania (Hoover, 2002). This suggests that educational efforts on the use of growing degree days and plant phenology can and should be expanded within Pennsylvania.

Very few respondents reported specifically employing traps, foliage samples, or indicator plants as a technique for monitoring insect or mite, although, greater than half reported using a combination of techniques. Lack of documented use of these monitoring techniques provides an opportunity to develop both demonstrations and educational programs centered around their effectiveness, deployment, maintenance, and interpretation on results based on the target insect.

Among the groups, a large proportion of respondents were less confident in their skills to accurately identify insect, disease, and weed problems based on their choice of "sometimes" rather than "always" when completing the survey. This suggests that continued education on identification skills would benefit respondents in each group and strengthen overall confidence.

A majority (83% to 88%) considered insect or mite damage and weed population (7%) severity and nearly all segment respondents (80% to 90%) considered disease incidence and severity prior to treatment. By considering severity and incidence prior to treatment suggests that most of the respondents have learned to evaluate the pest evidence prior to action.

Nearly one-third (26% to 38%) of respondents would like to do more with nursery layout based on key plants and pests, isolation of plants with pest problems, and weed management. Segment respondents (24% to 35%) reported a future interest in using insecticidal soaps and natural products for insect or mite control, targeting the vulnerable point in weed life cycle for treatment, evaluate weed sources, and use of preemergence herbicides to reduce weed pressure. The above interest for more information and experience provides direction for future education and demonstration programs for extension personnel in Pennsylvania.

Nearly all (83% to 90%) questioned the effectiveness of alternatives to chemical pesticides as a limitation to IPM, while greater than half (51% to 60%) agreed that using fewer chemical pesticides would lower their nursery’s risk of being sued. Less than half (34% to 46%) felt their customers would appreciate the use of IPM practices and less than one-third (18% to 32%) considered natural enemies as a cost effective control option. Reduced pesticide use is a recognized benefit of IPM; however, further evidence on the effectiveness of alternative controls, cost effectiveness of natural enemies, and a clearly defined market benefit to customers must be developed in order to convince a majority of the respondents to adopt IPM strategies completely.

Conclusions

Three distinct IPM practitioner segments can be identified in Pennsylvania. The “IPM Savvy” appear to be proficient and comfortable with the level of monitoring and decision-making criteria they are currently employing. They will most likely continue to incorporate new ideas into their IPM programs to satisfy their customers’ needs as well as their own. The “Part-time IPMers” appear to be the segment with the greatest immediate educational potential through face-to-face extension programs, fact sheets, and pocket guides designed around IPM skills training, implementation strategies, and cost-benefit demonstrations. Only a small percentage of the “Reluctant IPMer” segment uses IPM practices or has an interest in increasing future involvement. The “Reluctant IPMer” segment needs more education to convince them to use IPM practices. Focusing programming toward the “Part-time IPMers” may result in new techniques and tools to further educate the “Reluctant IPMer.”

As a whole, Pennsylvania growers have a high awareness of IPM practices; however, continued education is warranted to enhance pest monitoring and identification skills, use of beneficiais, and recordkeeping. Additional research and education is also needed to demonstrate effectiveness of chemical alternatives, cost effectiveness of IPM practices, and marketing benefits of employing IPM practices in the nursery industry.

Literature Cited

Higginbotham, J.S. 1993. Pest control; IPM use by nursery growers. Amer. Nurs. 177(12):70–74,


