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Lawn Care and Landscape Maintenance Professional Acceptance of Insect- and Disease-resistant Ornamental Plants

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***Abstract*. Although lawn care and landscape maintenance professionals appear increasingly willing to use Integrated Pest Management (IPM) strategies and adopt nonchemical pest management alternatives into management practices, the opinions of landscape management professionals have not been assessed regarding anticipated influences of increased use of insect- and disease-resistant ornamental plants on grounds management activities, client satisfaction, or business profitability. Lawn care and landscape professionals are well positioned to implement many IPM practices into landscape use and to educate their consumer clients about ecologically sustainable landscape designs and beneficial management techniques. Conversely, if some of these professionals are unwilling to advocate installation of ornamental host plants that are resistant to certain pests or diseases, market success of such plants can be limited. To better understand perceptions of green industry professionals related to these issues, we surveyed lawn care and landscape business owners and employees to categorize their perceptions about insect- or disease-resistant ornamental plants and qualified their beliefs in relation to both personal and firm demographics. A total of 391 completed surveys were received from Tennessee, Florida, and Georgia participants. Data analyses revealed that lawn care and landscape maintenance professionals largely believe that insect- and disease-resistant plants will benefit their businesses and should result in increased client satisfaction. Only ≈4% of respondents stated concern that business would incur at least some negative effect if pest-resistant plants were made more available or used in greater numbers in client landscapes. Among all respondents, there was an average expectation that 60% or more of plants within a given client's landscape would have to be resistant to insect pests or plant diseases to result in a decrease in company profits. If insect- and disease-resistant ornamental plants were used more widely in client landscapes, respondents expected that the required number of site visits to client landscapes would remain unchanged and that moderate reductions in insecticide and fungicide use would result.**

In past surveys, lawn care and landscape maintenance professionals have reported their willingness to adopt Integrated Pest Management (IPM) strategies and use nonchemical pest management alternatives (Braman et al., 1998a; Garber and Bondari, 1996; Hubbell et al., 1997). Garden and landscape enthusiasts are also willing to seek pest- and disease-resistant ornamental plants for residential landscape use despite initial public skepticism about IPM (Ball, 1986; Garber and Bondari, 1992, 1996; Holmes and Davidson, 1984; Klingeman et al., 2004, 2006; Koehler, 1989; Stewart et al., 2002). Numerous ornamental plant species and cultivars have been exposed to pests and plant diseases in university trials and then evaluated for subsequent injury. Results of some of these studies have been compiled into published plant lists highlighting plants that demonstrate tolerance and resistance to specific pests and diseases (Smith-Fiola, 1995). Ornamental host plant resistance (HPR) to pests and diseases is an integral component of successful landscape IPM. Increased use of pest- and disease-resistant ornamental plants would offer advantages to grounds maintenance professionals by reducing the time needed to monitor key plants in client landscapes (Stewart et al., 2002) and would address stated needs for a "total system approach" to IPM by affecting a shift in management behavior with benefits that persist for longer durations within the environment (Lewis et al., 1997).

Although end-users of ornamental plants are interested in pest resistance (Braman et al., 1998a, 1998b; Garber and Bondari, 1992, 1996), opinions of landscape management professionals have not been assessed, particularly with regard to how ornamental HPR may be perceived to affect company profitability. If insect- and disease-resistant plants are widely adopted by the gardening public, it is possible that landscape maintenance firms would have real or perceived loss of income resulting from reduced need for pesticide applications or fewer onsite visits to client landscapes. We consider landscape management professionals to include grounds managers, landscape designers, landscape architects, pesticide spray technicians, and others. The extent to which this peer group is unwilling to adopt or advocate use of resistant ornamental host plants (e.g., because of concerns about profit decline or client unwillingness to accept plant substitutes) will place constraints on the market success of these plants as new cultivars are introduced to commercial trade. Therefore, objectives of this study were to question landscape management professionals and categorize their perceptions about the potential for insect- or disease-resistant ornamental plants to affect company or personal profitability as well as client satisfaction and to qualify these beliefs as related both to personal and firm demographics.

Materials and Methods

A four-page questionnaire was developed and pretested with participants of the Jan. 2006 Grounds Maintenance Short Course in Knoxville, TN, to assess perceptions of lawn care and landscape maintenance professionals about insect- and disease-resistant ornamental plants. The final survey was then mailed in April by the UGA Survey Center to more than 1500 landscape management professionals and firms registered in Tennessee and Georgia. Anticipating a response rate from the direct mail survey of ≈10% (Reed, 1999), mailed surveys were also supplemented with direct delivery to landscape management professionals attending service-learning workshops (from June 2006 through Oct. 2007) at the Tennessee Nursery and Landscape Association winter workshop in Pigeon Forge, TN; Middle Tennessee Nursery Association Trade Show in McMinnville, TN; Spring Express Landscape Seminar in Chattanooga, TN; Tri-Cities Landscape Seminar

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in Jonesboro, TN; Southern Nursery Association Tech Shop in Atlanta, GA; Southeastern Greenhouse Conference in Greeneville, SC; and three separate Georgia/Florida Green Industry Update Conferences in Jacksonville, FL, and Quincy, FL. Respondents at outreach sessions who indicated they had already completed the survey were either excused from participation in the subsequent assessment or their notated second survey was excluded from data analyses. Respondents were able to anonymously complete the questionnaire to encourage them to provide personal demographic information. They also described personal experiences within the green industry, professional interactions with clients, and their personal participation in practices related to grounds and landscape maintenance (Tables 1 and 2).

Modified Likert scales, in which 1 was "not important" and 7 was "extremely important" to respondents, were used to assess perceptions about management characteristics that professionals considered ideal for a customer's landscape. Similarly, modified Likert scales were used to assess willingness to recommend insect- and disease-resistant ornamental plants for use or replacement in client landscapes, relative willingness to pay for resistant ornamental plants, and to compare insect and disease resistance between introduced and U.S. native ornamental plants. A series of questions was posed to assess expectations about business profitability and action outcomes to firms if the respondent were to plant insect- and disease-resistant ornamental plants in client landscapes. Participants were also asked to indicate on a sliding scale marked at 10% intervals and labeled with 0% = no insect- and disease-resistant plants in the client landscape, 50% and 100% = the entire ornamental plant assemblage comprised of insect- and disease-resistant plants, the point beyond which additional insect- and disease-resistant ornamental plants were expected to decrease company profits if planted in a clients' landscape. Respondents were offered the choice to state they "[Did] not think insect or disease resistant plants would yield profit" (Table 3).

To obtain a metric that gauged respondent familiarity with insect- and disease-resistant ornamental plants, respondents were asked to choose which plant was more resistant to a specific insect pest or plant disease from a pair of ornamental plants selected as complimentary in aesthetic form and landscape function and for which resistance levels have been reported. Participants were encouraged to acknowledge if their selection was merely a best guess. To generate a "knowledge" variable, all blank, incorrect, and guess responses were excluded and correct responses were subjected to Cronbach's reliability analysis (Table 4). Because responses to these questions yielded a coefficient alpha of 0.83 when each question was omitted, the reliability (range = 0.79 to 0.83) remained above the acceptable threshold of 0.70 (Nunnally, 1978); correct scores for all 10 susceptibility/resistance choices were summed to generate a valid host plant resistance "knowledge" value. When significant, differences in means were assessed in multiple comparisons using Tukey's honestly significant difference test (SPSS, 2003).

Unequal sample sizes resulted from excluding answers that were missing or marked as "don't know" by respondents. Valid responses were tested for equal variance and normality and then assessed using χ^2 comparisons, Student's *t* test, and Pearson's correlation coefficient test. Two-factor multivariate analysis of variance tested the relationship of respondent expectations about how increased availability of insect- and disease-resistant ornamental plants would influence landscape business performance with self-stated expectations of how increased insect- and disease-resistant ornamental plant use in client landscapes would affect key landscape company performance parameters. If the overall χ^2 was significant, adjusted residual values (a nonparametric equivalent of z-scores) for cell percentage in each subgroup were examined. Adjusted residual scores greater than 2.0 and less than –2.0 for a given subgroup percentage indicated that the subgroup differed significantly ($P \leq 0.05$) from the overall group percentage (Haberman, 1978). Response pools that violated assumptions of equal variance and normality by Shapiro-Wilk and Levene tests ($P \geq 0.05$ and $P \leq 0.05$, respectively) were analyzed using Kruskal-Wallis' nonparametric test (SPSS, 2003).

Table 1. Demographic characteristics that describe the lawn care and landscape maintenance professionals who returned a completed four-page questionnaire.

Number of respondents	392
Characteristic	Percentage of respondents
Professional occupation	
Owner/general manager	56
Landscape crew member	9
Office/sales/company support	4
Landscape crew foreman	12
Did not work in landscape maintenance	7
Other	9
Did not respond	3
Number of clients served (range)	
Fewer than 20	11
21 to 50	14
51 to 100	16
101 to 200	11
201 to 500	9
More than 500	4
Did not respond	35
Gender	
Male	79
Female	17
Did not respond	4
Age	
15 to 24	2
25 to 34	16
35 to 44	25
45 to 54	35
55 to 64	15
Older than 65	3
Did not respond	<3
Highest level of education completed	
High school	19
Some college	27
Associate's degree	10
Bachelor's degree	27
Some graduate school	5
Master's degree	7
Doctorate	<1
Did not respond	4
Number of years earning income as a landscape management professional	Mean ± SEM (n = 322) 16 (±0.56)

Results and Discussion

By Nov. 2007, 391 completed surveys were received from respondents contacted either by mail (n = 160) or by direct delivery in conjunction with outreach activities (n = 231). Of the landscape management professionals who returned surveys, 52% worked in Tennessee, 28% were located in Georgia, 16% were from Florida, and 4% were from all other states. Respondent job responsibilities were as sole employees or owners of the business (56%), landscape crew forepersons (12%), and crewmembers (9%). Approximately 49% had achieved at least a Bachelor's degree and 21% of respondents had some level of postgraduate education. Nearly half of respondents were 45 years old or younger, were most likely to be male (82%),

Table 2. Summary statistics of lawn care and landscape maintenance professionals' responses to questions about insect- and disease-resistant ornamental plants.

Variable	'Yes' (%)	'No' (%)	'When Asked' (%)
Does your landscaping organization:			
[Q1] treat for insects or diseases in client landscapes?	231 (59)	84 (21)	80 (20)
[Q2] plant new or replace dead plants in client landscapes?	303 (77)	53 (13)	38 (10)
[Q3] maintain a list of insect- or disease-resistant ornamental plants for use in client landscapes?	216 (59)	152 (41)	—
[Q4] actively promote at least one insect- or disease-resistant plant or cultivar to client landscapes?	161 (47)	185 (54)	—
[Q5] Are you aware of any published lists of insect- or disease-resistant ornamental plants?	72 (18)	325 (82)	—
[Q6] Are you the person selecting ornamental plants for use or replacement in client landscapes?	216 (54)	100 (25)	82 (21)
[Q7] If "no", who does recommend ornamental plants for client landscapes?			
a. Our clients	45 (30)	104 (70)	—
b. Our company's landscape designer	71 (52)	77 (48)	—
c. Landscape contractor (external)	20 (13)	128 (87)	—
d. Landscape architect (external)	33 (22)	115 (78)	—
e. I do not know	14 (10)	134 (90)	—

Table 3. Summary statistics of lawn care and landscape maintenance professionals' responses to questions about insect- and disease-resistant ornamental plants.

Variable:	Mean (SEM)	Minimum	Maximum
[Q8] If you could design a perfect landscape for a customer, how important would the following characteristics be to you?			
a. Weed-free	6.06 (0.06)	1	7[z]
b. Less mowing	4.53 (0.08)	1	7
c. Less watering	5.33 (0.08)	1	7
d. Insect-resistant	5.92 (0.06)	1	7
e. Disease-resistant	6.03 (0.06)	1	7
f. Environmentally "friendly"	5.76 (0.07)	1	7
g. Healthy looking	6.61 (0.04)	1	7
h. Aesthetically pleasing	6.55 (0.04)	1	7
[Q9] Given a fair price and equivalent plant quality, how willing would you be to insect- or disease-resistant ornamental plants for use or recommend replacement in client landscapes?	6.16 (0.06)	2	7[y]
[Q10] If you planted insect- or disease-resistant ornamental plants in client landscapes, how would it affect your company's…			
a. Number of annual site visits?	3.85 (0.07)	1	7[x]
b. Amount of *insecticides* applied?	2.93 (0.07)	1	7
c. Amount of *fungicides* applied?	2.83 (0.07)	1	7
d. Customer/client satisfaction?	5.02 (0.08)	1	7
e. Company profits?	4.97 (0.07)	1	7
f. "New" insect/disease problems?	3.91 (0.08)	1	7
g. Cost of resistant plants?	4.56 (0.07)	1	7
[Q11] Would greater availability of insect- or disease-resistant plants [be extremely bad, have no effect, or be extremely good] for your business?	5.51 (0.06)	2	7[w]
[Q12] Approximately what percent of a client's landscape could be planted with insect- or disease-resistant ornamental plants without decreasing company profits, if any?	60.90 (1.35)	0	100[v]
[Q13] Compared with insect- and disease-susceptible plants, how much do you believe clients would be willing to pay for similar but insect- and disease-resistant landscape plants?	4.87 (0.04)	2	7[u]
[Q14] In terms of insect or disease resistance, how do U.S. native landscape plants compare with landscape plants imported from other countries?	4.80 (0.06)	1	7[t]

[z]Scalar range: 0 = "not important" to 7 = "very important".
[y]Scalar range: 1 = "not at all willing" to 7 = "very willing".
[x]Scalar range: 1 = "decrease greatly" to 7 = "increase greatly".
[w]Scalar range: 1 = "extremely bad for business" to 7 = "extremely good for business".
[v]Scalar range: 0 = "no percent of landscape plants" to 100 = "100% of landscape plants".
[u]Scalar range: 1 = "much less money" to 7 = "much more money".
[t]Scalar range: 1 = "much less resistance" to 7 = "much more resistance".

and averaged 16 years of professional green industry experience (Table 1).

With regard to duties performed, more than 77% of respondents had personally either planted new plants or replaced dead plants in client landscapes, ≈59% reported they themselves treated for landscape insect and disease problems in client landscapes, whereas an additional 20% stated they would provide that service for clients "when asked" to do so (Table 2). Willingness to recommend insect- or disease-resistant ornamental plants to clients was not correlated with years of green industry experience [$r_{(314)} = 0.062$; $P = 0.27$] and did not differ if the respondent was the landscape business owner (n = 219) versus a landscape crew or foreperson (n = 82) [$\chi^2_{(1)} = 3.94$; $P= 0.06$; $r_{(254)} = -0.045$; $P = 0.48$]. Using Kruskal-Wallis' test for non-normally distributed data, willingness to recommend insect- and disease-resistant ornamental plants was also not explained as a function of the number of clients that respondents serve [$\chi^2_{(5)} = 9.23$; $P = 0.10$] but was positively correlated with increasing respondent age [$\chi^2_{(5)} = 13.86$; $P = 0.017$; $r_{(380)} = 0.197$; $P < 0.0001$]. Among respondents who provided gender data, women (n = 17) were more willing than men [n = 79; $\chi^2_{(1)} = 10.20$; $P < 0.001$] to recommend insect- or disease-resistant ornamental plants to clients.

Landscape management professionals indicated they would be equally likely to recommend insect- or disease-resistant plants to clients (Q9) (Fig. 1), whether landscape managers themselves treated for pests and diseases in client landscapes [$\chi^2_{(8)} = 13.3$; $P = 0.101$]. Performance of management actions, like applying pesticides for insects and diseases, also did not predict landscape professional beliefs regarding influence on several proposed outcomes when questioned

Table 4. Ability of lawn care and landscape maintenance professionals to correctly identify which plant has resistance to specific insect and disease problems and the reliability of each question's contribution to creation of a new host plant resistance knowledge variable.

Host plant resistance to pests or diseases	Correct responses (%)	Cronbach's alpha (if variable is deleted)
Insect pests		
Eastern tent caterpillar		
Carolina Silverbell (*Halesia tetraptera*)*[z]	170 (44)	0.806
Kwanzan Cherry (*Prunus serrulata* Kwanzan)		
Bagworms		
Eastern Arborvitae (*Thuja occidentalis*)		
Japanese Cryptomeria (*Cryptomeria japonica*)*	185 (47)	0.797
Japanese beetles		
Amer. Hornbeam/Ironwood (*Carpinus caroliniana*)*	102 (26)	0.807
Linden = Basswood (*Tilia* spp.)		
Spruce spider mites		
Eastern Hemlock (*Tsuga canadensis*)		
Japanese Yew (*Taxus cuspidata*)*	118 (30)	0.799
Twospotted spider mites		
Inkberry Holly (*Ilex glabra*)*	99 (25)	0.802
Japanese Holly (*Ilex crenata*)		
Plant diseases		
Black spot		
Double Delight Hybrid Tea Rose		
Peace Hybrid Tea Rose*	50 (13)	0.834
Botryosphaeria canker		
Atlantic White Cedar (*Chamaecyparis thyoides*)*	109 (28)	0.809
Leyland Cypress (× *Cupressocyparis leylandii*)		
Crown gall		
Burning Bush Euonymus (*E. alatus*)*	98 (25)	0.806
Wintercreeper Euonymus (*E. fortunei*)		
Fire blight		
Red Splendor Crabapple (*Malus* Red Splendor)		
Sargent Crab Apple (*Malus sargentii*)*	61 (16)	0.830
Powdery mildew		
Flowering Dogwood (*Cornus florida*)		
Kousa Dogwood (*C. kousa*)*	184 (47)	0.785
Average host plant resistance (HPR) knowledge score	30.1 ± 1.4	
Overall reliability of all variables (Cronbach's alpha)	0.824	
Landscape professional's home state	Mean HPR knowledge score (%)	
Florida (n = 59)	15.1 b[y]	
Georgia (n = 106)	21.7 b	
Tennessee (n = 192)	38.2 a	

[z]Asterisk (*) denotes the species or cultivar correctly identified to be resistant to the named insect pest or plant disease.
[y]Means followed by the same letter are not significantly different by Tukey's honestly significant difference at $P < 0.05$.

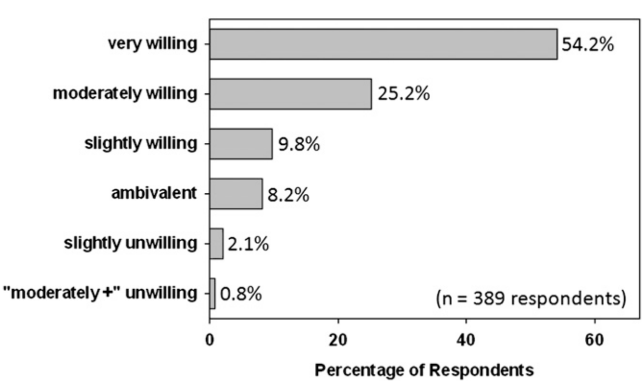

Fig. 1. Respondent's self-stated "willingness-to-recommend" insect- and disease-resistant ornamental plants for installation or replacement in their customer client's landscapes.

about the use of insect- or disease-resistant plants in client landscapes (Q10). Expectations did not differ about the number of site visits to client landscapes [$\chi^2_{(14)} = 9.0$; $P = 0.69$], anticipated client satisfaction [$\chi^2_{(12)} = 17.06$; $P = 0.15$], and beliefs about company profits [$\chi^2_{(12)} = 12.88$; $P = 0.38$] between managers who did and did not apply pesticides in client landscapes. By contrast, landscape managers who treated with pesticides in client landscapes expected use of insecticides [$\chi^2_{(14)} = 32.19$; $P = 0.004$] and fungicides [$\chi^2_{(12)} = 44.98$; $P < 0.0001$] to "decline somewhat" rather than "stay the same." When adjusted residual values were considered, landscape managers who reported that they treated for pests and diseases in client landscapes were more likely than professional managers who do not treat to expect that fewer "new" insect or disease problems would arise after installation of insect- or disease-resistant plants in clients' landscapes [$\chi^2_{(12)} = 28.39$; $P = 0.005$]. However, average number of annual site visits was expected to remain about the same regardless of respondent responsibility for treating landscape plants for pests and diseases [$\chi^2_{(12)} = 9.07$; $P < 0.70$].

Few landscape management professionals believed that increased use of insect- and disease-resistant ornamental plants in the landscape would negatively affect business. To enable comparisons among response categories, "slight," "moderate," and "extremely negative effect" responses were pooled. Consequently, just 4% of all surveyed respondents anticipated "some negative effect" to business as a result of use of these plants. Instead, increased availability of insect- and disease-resistant ornamental plants was expected on average to offer between "slight" and "moderate" benefits to company business (Fig. 2). In general, green industry professionals believed that company profits would increase "slightly" (Table 3) if they adopted increased use of insect- and disease-resistant ornamental plants. Averaged among all responses, the greatest perceived gains from increased availability of insect- and disease-resistant plants were expected to occur through increased client satisfaction (Table 3). In addition, ≈45% of respondents anticipated that clients will be willing to pay slightly more, whereas 20% expected to be able to charge "moderate" to "much" more for these plants (Fig. 3). Among professionals who perceived insect- and disease-resistant ornamental plants to be good for business, there was a higher than expected willingness to recommend those plants to clients [$\chi^2_{(16)}$ = 79.01; P < 0.0001]. With regard to relative pest resistance of U.S. native plant species, ≈59% of landscape management professionals believe that U.S. native plants provide at least slightly more resistance to insect and disease pests than nonnative ornamental plants in the landscape (Fig. 4).

Cronbach's coefficient showed that people's knowledge was reliably consistent between questions (Table 4). Such knowledge by landscape professionals provided little predictive insight regarding overall influence of insect- and disease-resistant ornamental plants on company business (Q9) [$\chi^2_{(36)}$ = 37.19; P = 0.42] or willingness to recommend insect- and disease-resistant ornamental plants to clients (Q11) [$\chi^2_{(36)}$ = 34.16; P = 0.56]. Level of host plant resistance knowledge was not strongly correlated with the participant's response to questions of insecticide and fungicide use in landscapes (Q10b), client satisfaction (Q10c), and emergence of "new" insect or disease problems on landscape plants (Q10d) [$\chi^2_{(54)}$ = 55.44 to 44.33; P = 0.82 to 0.42]. By contrast, adjusted residual values indicated that respondents having the least knowledge about insect- and disease-resistant ornamental plants were more likely than knowledgeable peers to expect a greater need for site visits to client landscapes (Q10a) [$\chi^2_{(54)}$ = 75.04; P = 0.03], less potential benefit to company profits (Q10e) [$\chi^2_{(54)}$ = 72.15; P = 0.05], and were more likely than expected to believe that resistant ornamental plants should cost less at point of purchase (Q10f) [$\chi^2_{(54)}$ = 77.21; P = 0.02].

Despite self-stated exposure to management actions for pests and plant diseases, such professional practices alone did not appear to be informative about respondents' level of HPR knowledge. Indeed, landscape management professionals who did not treat pest and disease problems in clients' landscapes had a similar level of knowledge about ornamental plant cultivars that provided HPR to key pests and plant diseases as professionals who indicated they did personally manage pests [$\chi^2_{(9)}$ = 12.74; P = 0.18]. Grounds managers who had greater numbers of clients were no more likely to correctly identify insect- and disease-resistant plants than professionals who worked in fewer client landscapes [$\chi^2_{(45)}$ = 52.97; P = 0.19]. As expected, however, grounds managers were more likely to correctly identify a greater proportion of pest-resistant plants as years of landscape management experience increased [$r_{(318)}$ = 0.248; P < 0.0001]. By contrast, correct answers were not correlated with highest level of education achieved [$r_{(312)}$ = 0.050; P = 0.38]. Respondents from Tennessee had the highest average HPR knowledge scores (Table 4), but also averaged 18.3 years of landscape management experience, more than respondents from both Georgia (16.4 years) and Florida (9.5 years) (F = 12.19; df = 2, 299; P < 0.0001).

Approximately half of surveyed landscape management professionals believed that company profits were unlikely to be restricted unless 60% or more of plants in a client's landscape possessed resistance to some insect pests or plant diseases. Gender did play a slight role in explaining respondent belief about this percentage. When compared

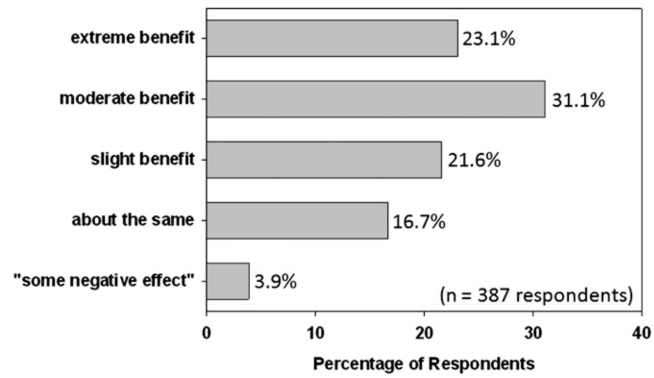

Fig. 2. Lawn care and landscape maintenance professionals responded about how increased availability of insect- and disease-resistant ornamental plants would be expected to influence their companies' businesses.

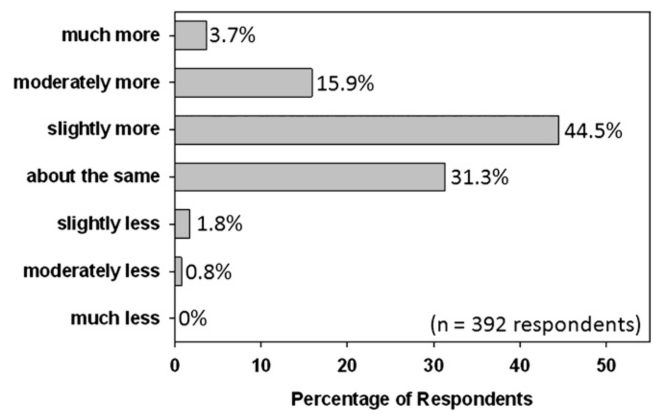

Fig. 3. Respondent's expectations about their landscape client's "willingness to pay" for insect- and disease-resistant ornamental landscape plants.

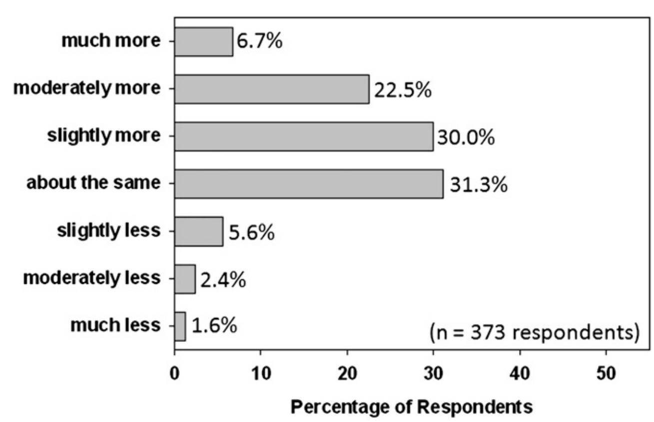

Fig. 4. Lawn care and landscape maintenance professionals' perceptions about the relative resistance to insect and disease pests exhibited by U.S. native versus nonnative ornamental landscape plants.

with men (n = 276), women respondents (n = 53) had an average expectation that ≈10% more insect- and disease-resistant plants would be needed in a client's landscape to likely affect a loss to their company's profitability [$t_{(2.034,\ 327)}$, $P = 0.04$] (Fig. 5).

The survey revealed several relationships that help explain why landscape management professionals anticipate increased availability and use of insect- and disease-resistant ornamental plants will either help or hinder company productivity and perception by clients. Green industry professionals who believed that insect- and disease-resistant ornamental plants would provide "extreme" or "moderate" benefits to business performance also expected company profits to increase [$\chi^2_{(24)} = 115.79$; $P < 0.0001$; $r_{(371)} = 0.259$; $P < 0.0001$] (Table 5). This expectation was not related to an increase in site visitation to client landscapes, which were expected to remain about the same [$r_{(377)} = –0.078$; $P = 0.13$] or a decrease in anticipated need for insecticide [$r_{(370)} = 0.086$; $P = 0.10$] and fungicide [$r_{(372)} = 0.045$; $P = 0.38$] applications. Instead, grounds managers who believed that increased availability and use of insect- and disease-resistant ornamental plants would benefit business also expected that fewer "new" pest problems would emerge in client landscapes [$\chi^2_{(24)} = 85.62$; $P < 0.0001$; $r_{(366)} = –0.191$; $P < 0.0001$]. In turn, these landscape management professionals also believed that the greatest benefits to business profit and performance were realized by higher costs that could be charged for insect- or disease-resistant ornamental plants [$\chi^2_{(24)} = 94.66$; $P < 0.0001$; $r_{(370)} = 0.167$; $P < 0.0001$] as well as the expectation that clients would have greater satisfaction with the landscapes under managed care [$\chi^2_{(24)} = 142.10$; $P < 0.0001$; $r_{(376)} = 0.391$; $P < 0.0001$] (Table 5).

Conclusions

In many past efforts, plant resistance to pests or disease has not been specifically addressed with regard to green industry professional adoption or acceptance of IPM components. For example, although Hubbell et al. (1997) acknowledged that use of native plants can function within a landscape IPM program to improve performance of shrubs and trees in landscapes, they chose not to include resistance to pests or diseases among either native or nonnative plant selections as a factor in their survey model, in part because only limited information was available regarding recommendations about insect or disease resistance in ornamental plants. In their survey, they did determine that older, smaller, and less capitalized firms were least likely to adopt high-intensity IPM in contrast to larger firms that were also found to more rapidly integrate into business practice new knowledge generated by university research and extension efforts. Similarly, a survey of Massachusetts cranberry growers found that older growers were typically more resistant to use of disease-resistant cranberry varieties (Blake et al., 2007). Although a survey by Kaine and Bewsell (2008) did not specifically investigate pest- and disease-resistant apple tree cultivars and species, the authors identified several situations that influenced IPM adoption by apple growers. Their respondents were reluctant to consider alternative management options if successful pest control practices existed. Respondents seem to be more willing to consider adopting IPM components if they had experienced repeated failures with controlling pests such as development of resistance to a pesticide, new pest emergence that resulted in overall control problems, and exclusion of successful control options resulting from various types of market or regulatory restrictions (Kaine and Bewsell, 2008).

In contrast to agronomic crops like wheat, for which yield and incomplete resistance of cultivars to multiple plant pathogens are the principal constraints to farmer acceptance of resistant varieties (Vanloqueren and Baret, 2008), interest among consumers for insect- and disease-resistant ornamental plants will be driven both by cultivar performance in the landscape and aesthetic appearance (Klingeman et al., 2004, 2006). Indeed, landscaping enthusiasts and home gardeners demonstrate an acute ability to discern plant injury caused by insects or plant diseases (Klingeman et al., 2000, 2001). A recent survey also indicates that unsatisfied green goods consumers may switch to pursue other hobby interests if early experiences with some garden and landscape plant purchases lead to regret, even if guarantees are included with plants at the time of sale (Dennis et al., 2005). Such behaviors among consumers corroborate the need that plant cultivars and species promoted to solve a landscape problem (e.g., resist injury from insects or plant diseases) do in fact satisfy that concern (Klingeman and Hall, 2006). Failure of a plant to perform up to stated expectation can be expected to drive some consumers away from hobby gardening and landscaping or trigger resentment, particularly if ornamental plant resistance was achieved through genetic engineering (Klingeman et al., 2006; Klingeman and Hall, 2006).

Among surveyed lawn care and landscape maintenance professionals, insect- and disease-resistant plants are largely anticipated to be beneficial both to business performance and to client satisfaction with plants in managed landscapes. Only ≈4% of respondents expected that increased availability of pest-resistant plants will have at least some negative effect on business. The shared belief that insect- and disease-resistant ornamental plants would profit lawn care and landscape businesses, including by green industry professionals who treat clients' plants for insect and disease pests, can be attributed in part by the average expectation that 60% or more of plants within a given client landscape must confer resistance to some insect or plant disease pests to affect business profits negatively. There is widespread evidence that nonnative insect pests and plant pathogens are capable of using native plant species as host resources (e.g., Asian longhorned beetle, emerald ash borer, and sudden oak death). A majority of landscape managers may expect U.S. native plants to be more capable of resisting attack by nonnative insect pests and plant diseases and therefore should be trained not to overlook these trees, shrubs, and herbaceous species in client landscapes. In short, landscape management professionals accept and are willing to promote insect- and disease-resistant ornamental plants. The net benefits of these findings include strong academic and commercial incentives to identify, grow, and promote insect- and disease-resistant ornamental plants for increased use within sustainable urban landscapes. In turn, the extent of unintended environmental costs will be limited by moderate reductions in insecticide and fungicide use when landscape management professionals and homeowners include these plants within their landscape designs.

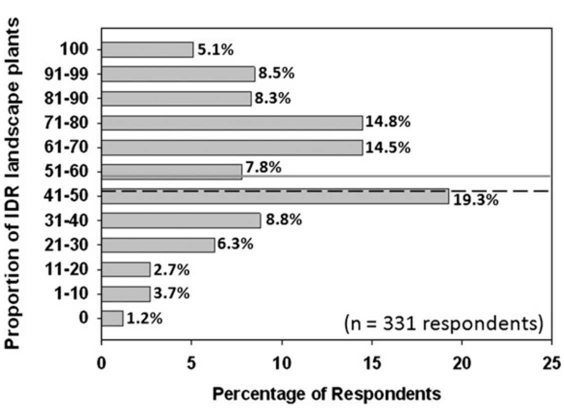

Fig. 5. Respondent belief about the proportion landscape plants planted into a client's landscape that if confer resistance to some insects and diseases (=IDR) would negatively affect company profits. By mean responses, women respondents (n = 53, solid line) indicated that a slightly higher proportion of insect- and disease-resistant ornamental plants must be planted into a landscape than men (n = 276, dashed line) by Student's *t* test ($P \leq 0.05$).

Table 5. Respondent expectation about how increased availability of insect- and disease-resistant (IDR) ornamental plants would influence landscape business performance (Q11) were correlated with self-stated beliefs about how increased IDR plant use in client landscapes would affect key landscape company performance parameters (Q10).

Parameter: Performance expectation	'Some negative' effect	No effect	Slight benefit	Moderate benefit	Extreme benefit
			Responses (%)[z]		
Client satisfaction					
Decrease greatly	4 (26.7)**[y]	6 (9.1)	4 (4.7)	3 (2.5)	1 (1.1)
Moderate decrease	2 (13.3)	5 (7.6)	8 (9.4)	5 (4.2)	0 (0)*
Slight decrease	2 (13.3)	1 (1.5)	6 (7.1)	3 (2.5)	5 (5.6)
Remain the same	1 (6.7)	20 (30.3)**	21 (24.7)**	18 (15.0)	5 (5.6)*
Slight increase	1 (6.7)	12 (18.2)	25 (29.4)**	32 (26.7)	8 (8.9)*
Moderate increase	2 (13.3)	19 (28.8)	18 (21.2)	45 (37.5)**	27 (30.0)
Increase greatly	3 (20.0)	3 (4.5)*	3 (3.5)*	14 (11.7)*	44 (48.9)**
χ^2			$\chi^2_{(24)} = 142.10$; $P < 0.0001$		
Pearson correlation			$r_{(376)} = 0.391$; $P < 0.0001$		
Company profits					
Decrease greatly	3 (20.0)**	0 (0)	2 (2.4)	1 (0.8)	0 (0)
Moderate decrease	1 (6.7)	1 (1.6)	2 (2.4)	1 (0.8)	1 (1.1)
Slight decrease	1 (6.7)	6 (9.4)	4 (4.8)	6 (5.0)	1 (1.1)
Remain the same	1 (6.7)*	31 (48.4)*	38 (45.2)**	33 (27.5)	13 (14.8)*
Slight increase	2 (13.3)	7 (10.9)**	20 (23.8)	44 (36.7)**	24 (27.3)
Moderate increase	2 (13.3)	12 (18.8)	16 (19.0)	23 (19.2)	18 (20.5)
Increase greatly	5 (33.3)**	7 (10.9)	2 (2.4)*	12 (10.0)*	31 (35.2)**
χ^2			$\chi^2_{(24)} = 115.79$; $P < 0.0001$		
Pearson correlation			$r_{(371)} = 0.259$; $P < 0.0001$		
"New" pest and disease problems					
Decrease greatly	2 (13.3)	0 (0)*	2 (2.4)	5 (4.3)	9 (10.2)**
Moderate decrease	0 (0)	7 (11.3)	4 (4.8)*	18 (15.4)	22 (25.0)**
Slight decrease	1 (6.7)	6 (9.7)	18 (21.4)	24 (20.5)	9 (10.2)
Remain the same	3 (20.0)	29 (46.8)	39 (46.4)*	43 (36.8)	21 (23.9)*
Slight increase	1 (6.7)	10 (16.1)	14 (16.7)	16 (13.7)	9 (10.2)
Moderate increase	1 (6.7)	5 (8.1)	6 (7.1)	7 (6.0)	5 (5.7)
Increase greatly	7 (46.7)**	5 (8.1)	1 (1.2)*	4 (3.4)*	13 (14.8)**
χ^2			$\chi^2_{(24)} = 85.62$; $P < 0.0001$		
Pearson correlation			$r_{(366)} = -0.191$; $P < 0.0001$		
Cost of insect- and disease-resistant plants					
Decrease greatly	5 (33.5)**	0 (0)	0 (0)	2 (1.7)	4 (4.5)
Moderate decrease	0 (0)	4 (6.3)	4 (4.7)	2 (1.7)	1 (1.1)
Slight decrease	0 (0)	7 (10.9)	10 (11.8)	14 (11.9)	4 (4.5)
Remain the same	4 (26.7)	31 (48.4)**	27 (31.8)	33 (28.0)	28 (31.8)
Slight increase	3 (20.0)	9 (14.1)*	30 (35.3)	45 (38.1)**	22 (25.0)
Moderate increase	1 (6.7)	6 (9.4)	12 (14.1)	18 (15.3)	16 (18.2)
Increase greatly	2 (13.3)	7 (10.9)	2 (2.4)*	4 (3.4)*	13 (14.8)**
χ^2			$\chi^2_{(24)} = 94.66$; $P < 0.0001$		
Pearson correlation			$r_{(370)} = 0.167$; $P < 0.0001$		
Number of annual site visits					
Decrease greatly	1 (6.7)	2 (3.0)	0 (0)*	2 (1.7)	8 (8.7)*
Moderate decrease	2 (13.3)	7 (10.4)	8 (9.4)	11 (9.2)	14 (15.6)
Slight decrease	1 (6.7)	10 (14.9)	19 (22.4)	26 (21.7)	15 (16.7)
Remain the same	4 (26.7)	33 (49.3)	43 (50.6)	60 (50.0)	31 (34.4)*
Slight increase	3 (20.0)	6 (9.0)	11 (12.9)	8 (6.7)	7 (7.8)
Moderate increase	2 (13.3)	6 (9.0)	3 (3.5)	10 (8.3)	7 (7.8)
Increase greatly	2 (13.3)	3 (4.5)	1 (1.2)	3 (2.5)	8 (8.9)*
χ^2			$\chi^2_{(24)} = 38.99$; $P < 0.03$		
Pearson correlation			$r_{(377)} = -0.078$; $P = 0.13$		
Amount of insecticides applied					
Decrease greatly	6 (42.9)*	6 (9.4)	3 (3.6)**	8 (6.7)**	23 (25.6)*
Moderate decrease	6 (42.9)	12 (18.8)**	29 (34.5)	45 (37.5)	24 (26.7)
Slight decrease	0 (0)**	18 (28.1)	25 (29.8)	37 (30.8)	13 (14.4)**
Remain the same	1 (7.1)	26 (40.7)*	20 (23.8)	20 (16.7)	13 (14.4)
Slight increase	0 (0)	0 (0)	6 (7.1)	6 (5.0)	6 (6.7)
Moderate increase	0 (0)	2 (3.1)	1 (1.2)	3 (2.5)	1 (1.1)
Increase greatly	1 (7.1)	0 (0)	0 (0)	1 (0.8)	10 (11.1)*
χ^2			$\chi^2_{(28)} = 96.46$; $P < 0.0001$		
Pearson correlation			$r_{(372)} = 0.045$; $P = 0.38$		
Amount of fungicides applied					
Decrease greatly	6 (42.9)*	8 (12.7)	5 (6.0)*	10 (9.1)*	22 (24.7)**
Moderate decrease	5 (35.7)	14 (22.2)	27 (32.1)	50 (45.5)**	24 (27.0)
Slight decrease	2 (14.3)	19 (30.2)	31 (36.9)**	30 (27.3)	17 (19.1)
Remain the same	1 (7.1)	19 (30.2)*	18 (21.4)	22 (20.0)	11 (12.4)
Slight increase	0 (0)	2 (3.2)	2 (2.4)	2 (1.8)	4 (4.5)
Moderate increase	0 (0)	1 (1.6)	1 (1.2)	6 (5.5)**	0 (0)
Increase greatly	0 (0)	0 (0)	0 (0)	0 (0)*	11 (12.4)**
χ^2			$\chi^2_{(24)} = 86.46$; $P < 0.0001$		
Pearson correlation			$r_{(370)} = 0.086$; $P = 0.10$		

[z]Values in parentheses represent the percentage of respondents holding viewpoint for that parameter within classification column.
[y]Asterisks indicate actual value was lower (*) or higher (**) than expected value for the group following adjusted residual analysis (Haberman, 1978).

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