

Changes in Production Practices by Green Industry Growers from 2009 to 2019¹

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Abstract

As a result of the latest economic recession (2007 to 2009), the U.S. green industry suffered significant economic losses, leading to major industry structural changes. To be competitive and effectively manage risk, nursery and greenhouse operators need reliable and up-to-date information. However, the availability of such data from federal government sources has become limited. This report summarizes the state of the industry, focusing on trends in production-related characteristics from the 2009, 2014, and 2019 survey years. As firm size increased, the percent of annual sales attributed to large plant species (e.g., deciduous trees) increased, while herbaceous (e.g., perennials) and specialty (e.g., Christmas tree) plants made up a larger percentage of annual sales for small- and medium-sized firms. The majority of respondents (73.3%) indicated a proportion of their sales came from container-grown plants. The most frequently used integrated pest management (IPM) practice was removal of infested plants (81%), followed by cultivation/hand weeding. As firm size increased, participation in IPM strategies increased. Interestingly, statistical differences between small- and medium-sized firms were infrequent, indicating similar levels of use; however, most of the IPM strategies used were more frequently employed by large-sized firms when compared to small- or medium-sized firms.

Index words: Container-grown, greenhouse, integrated pest management (IPM), nursery, ornamental plants.

Significance to the Horticulture Industry

The green industry is an important contributor to the U.S. agricultural economy and to individual regions and states (Hall et al. 2020). This broadly-based industry includes landscape services and wholesale-retail trade sectors existing in virtually all communities in the nation. In contrast, the production and manufacturing sectors (e.g., containers/pots, media, packaging, fertilizers, pesticides, greenhouse supplies, etc.) of the industry are concentrated in some states and contribute disproportionately to their state's GDP because out-of-state shipments bring new money into the local economies. The findings in this report are critical to our understanding of the structure-conduct-performance issues affecting the green industry, as well as the economy at large. Participants in the green industry now have access to data to assist them in making strategic decisions regarding future investments in their businesses. In addition, policy makers have more information to inform

their decisions regarding efficient allocation of resources among competing industries and interests.

Introduction

The Green Industry Research Consortium (GIRC) is a research team of horticulturists and agricultural economists across the country who collaborate on research pertinent to the challenges and opportunities faced by green industry firms. To guide these research efforts, the GIRC has regularly conducted national surveys every five years to document production, management, marketing, and trade practices within the U.S. green industry. The latest National Green Industry Survey was conducted in 2019 and gathered annualized information for 2018 or the most recent fiscal year completed (Hall et al. 2020, Khachatryan et al. 2020). It represents the seventh such effort by the GIRC since 1989 and provides the data on which this article is based.

Previous national surveys for 1988, 1993, 1998, 2003, 2008, and 2014 were reported by Brooker et al. (1990, 1995, 2000, 2005) and Hodges et al. (2010, 2015a). The objective of these surveys is to document changes in business practices over time and across regions and provide information useful to stakeholders, including nursery and greenhouse growers, re-wholesaler landscape distributors, garden center retailers, allied industry professionals, state university Extension personnel, and researchers. Additionally, this information is regularly used by industry stakeholders in communicating the relevance and economic impacts of the green industry at the county, state and regional levels (Hall 2010, Hall et al. 2011).

The objective of this article is to provide a regional analysis of the production practices of nursery and greenhouse growers in the U.S. using data from the last three national surveys conducted by the GIRC. Our hypothesis was that these practices would differ across regions of the U.S. in response to varying economic and environmental conditions. The specific production practices

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Table 1. Number of U.S. green industry firms in each size category, by survey year.

Survey Year (SY)	No. of Obs.	% of Sample	Small (\$10,000-\$124,999)	% of Sample	Medium (\$125,000-\$749,999)	% of Sample	Large (\$750,000+)	% of Sample
Total Sample	5216	100%	1076	21%	2681	51%	1459	28%
SY2009	2259	43%	480	9%	1114	21%	665	13%
SY2014	1747	34%	289	6%	985	19%	473	9%
SY2019	1210	23%	307	6%	582	11%	321	6%

es examined in this article include the plant types that are produced by growers (e.g., deciduous trees, herbaceous perennials, etc.) and how product mixes have shifted over the last three national surveys, the production methods (containers, balled and burlap, field grown, and so on) and how they have changed, and the shifts that have occurred in the adoption and use of integrated pest management (IPM) practices by green industry growers.

Materials and Methods

Survey design and implementation. The survey instrument used to collect data for this analysis is part of an ongoing research effort by the GIRC. This group consists of horticulturists, plant scientists, agricultural economists, and consumer behavior specialists from land-grant institutions across the U.S. The group collected data related to business, production, and marketing practices from green industry firms in 1989, 1994, 1999, 2004, 2009, 2014 and 2019. The survey content has remained fairly consistent over time in order to aid in time-series analyses of the data, with some questions edited or added to address industry and demand trends (e.g., social media and online marketing).

Each survey collected information from green industry firms in all 50 states. Firm contact lists were developed for each state primarily from the state's list of members of the National Plant Board (often the state Department of Agriculture or its equivalent) and supplemented with online commercial databases (<https://nationalplantboard.org>, Hall et al. 2011, Khachatryan et al. 2020). A random sample of firms were selected to receive the survey in each state. Traditionally, the surveys were distributed through mail, and more recent versions incorporated mail and online distribution methods (e.g., Qualtrics).

In this manuscript, data from the 2009, 2014 and 2019 data collection cycles were analyzed to assess industry trends from the post-recession years. The survey instrument consisted of several sections; see Hodges et al. (2010, 2015a, 2015b) and Hall et al. (2020) for a complete list of the survey questions. In this manuscript, questions addressing firm characteristics, IPM strategies, plant types (e.g., deciduous trees, etc.), and production methods (e.g., container-grown) were analyzed. Firm characteristics included the state where the main portion of the business was located. This information was used to sort firms into eight U.S. regions including Appalachian, Great Plains, Midwest, Mountain, Northeast, Pacific, Southcentral, and Southeast. Firms also reported their annual sales volumes, either provided as a specific amount or selected from a list of sales ranges. Participants were provided a list of plant types (e.g., herbaceous perennial, etc.) and production

methods (e.g., above-ground container production, etc.). For each product, they indicated the portion of their annual sales that came from that plant type. Next, they indicated the portion of annual sales attributed to each production method. For instance, if a firm only sold deciduous shrubs, they indicated that 100 percent of their annual sales were from deciduous shrubs. Similarly, if they only grew shrubs in above-ground containers, 100 percent of their annual sales were from above-ground container production. Lastly, participants were provided a list of IPM strategies and selected each action in which their firm participated.

Data analysis. Using data from the 2009, 2014, and 2019 survey years, this manuscript provides an overview of the production methods used in the green industry by firm size. Firm size was estimated using the reported annual sales and included small-sized firms (\$10,000 - \$124,999 in estimated annual sales), medium-sized firms (\$125,000 - \$749,999 in annual sales), and large-sized firms (\$750,000+ in annual sales). For consistency, only firms who identified as growers, wholesalers, or retailers of ornamental plants were used in the analysis ($n=5,984$). The 2014 and 2019 surveys also included landscape service-only firms. Given that the 2009 survey did not include landscape service firms, these firms ($n=441$) were excluded from the analysis. After excluding the landscape firms, there were a total of 5,984 observations across the three survey years. Firms with annual sales below \$10,000 were next excluded from analysis, for which 768 firms were removed to leave a total of 5,216 firms. Analysis of variance (ANOVA) and Tukey's honest significance test were used to test for significance between survey years and different sized firms within each survey year.

Tables 1, 2, and 3 illustrate the distribution of the firms by survey year, size, and region. Regardless of the survey year, most firms were in the medium-size category (51% of the sampled firms), followed by the large-size (28%), and then small-size categories (21%, Table 1). In terms of survey year, the largest number of participants occurred in 2009 (43% of the sample), followed by 2014 (34%), and then 2019 (23%). The majority of firms were located in the Southeast region (33% of sampled firms), followed by the Northeast (26%), Midwest (20%), Pacific (16%), Appalachian (14%), Southcentral (9%), Mountain (4%), and Great Plains regions (3%; Table 2). If the sample is divided by survey year and firm size (Table 3), in 2009, firms in the Southeast region were the most represented regardless of firm size. In 2014, the largest portion of small and medium firms were from the Northeast region while a bigger portion of large firms were from the Southeast region. In

Table 2. Regional distribution of participating U.S. green industry firms, by survey year.

Region	Total		SY2009		SY2014		SY2019	
	# of Firms	% of Sample	# of Firms	% of Sample	# of Firms	% of Sample	# of Firms	% of Sample
Appalachian	742	14%	305	12%	261	5%	176	3%
Great Plains	140	3%	44	1%	68	1%	28	1%
Midwest	1046	20%	424	8%	364	7%	258	5%
Mountain	222	4%	99	2%	68	1%	55	1%
Northeast	1341	26%	569	11%	500	10%	272	5%
Pacific	814	16%	408	8%	192	4%	214	4%
Southcentral	447	9%	184	4%	140	3%	123	2%
Southeast	1720	33%	689	13%	589	11%	442	9%
n	5,216	100%	2,259	43%	1,747	34%	1,210	23%

^aThree 2009 firms did not indicate a geographical location and were excluded from the table.

2019, firms were primarily from the Southeast region, regardless of size.

Results and Discussion

Participating firms indicated the percent of their annual sales attributed to different plant types (Table 4). Across survey years, the most sales were attributed to deciduous trees (10.9%), flowering annuals (10.6%), other plants (9.4%), evergreen trees (8.6%), herbaceous perennials (8.5%), other annuals (e.g., vegetables, fruits, herbs; 6.8%), flowering potted plants (5.8%), and broad-leaved evergreen shrubs (5.7%). The “other plants” category accounted for approximately 9% of sales and was included to capture plant categories that were not listed in the survey, including: ornamental grasses, palms, pineapple plants, aquatic plants, bamboo, orchids, bonsai, bromeliads, cut flowers, cacti and succulents, bulbs, and so forth. The percent of annual sales attributed to deciduous trees, evergreen trees, Christmas trees, and turfgrass sod was highest in the 2009 survey relative to the subsequent surveys. Broad-leaved evergreen shrubs sales percentages were higher in the 2009 survey than the 2014 survey. Herbaceous perennial sales were lower in the 2009 survey relative to the 2014 survey. Both flowering annual and other annual (vegetables, fruits, and herbs) sales were lower in the 2009 survey when compared to the 2014 and 2019 surveys. Flowering potted plant and fruit tree sales were higher in the 2019 survey when compared to the 2009 survey. The decrease in tree sales (e.g., deciduous trees, evergreen trees) and the increase in flowering annuals and other annuals (vegetables, fruits, herbs) may reflect changing consumer

preferences and living arrangements. For instance, more people are living in urban environments with limited outdoor space but exhibit increased interest in growing their own food (Garden Research 2021). Consequently, there may be more interest in edibles, fruits, vegetables and other compact plants relative to larger plants (e.g., trees) that require more space to grow.

The proportion of annual sales attributed to plant types was also evaluated by firm size and survey year (Table 5). In general, several differences can be observed when comparing firms by size. Large-sized firms had a larger percent of their sales attributed to deciduous trees, deciduous shrubs, vines, foliage, and turfgrass sod than small- or medium-sized firms. Large-sized firms had the largest percentage of sales attributed to broad-leaved evergreen shrubs and roses when compared to small- and medium-sized firms. When compared to large-sized firms, small- and medium-sized firms had a larger percent of their sales attributed to other plant types (e.g., ornamental grasses, succulents, etc.) and Christmas trees. Small-sized firms also sold a lower percent of narrow-leaved evergreen shrubs than large-sized firms. Small- and medium-sized firms had a similar percent of sales attributed to herbaceous perennials and other annuals (vegetables, fruits, herbs), which were higher than the percent of sales for those items among large-sized firms. Small-sized firms exhibited a higher percent of sales from flowering potted plants than medium- or large-sized firms. Together, these results indicate that large-sized firms primarily generate sales through the sale of larger types of plants (e.g., deciduous trees and shrubs, broad-leaved evergreen shrubs, vines, roses, foliage, turfgrass sod) whereas small- and medium-

Table 3. Regional distribution of participating U.S. green industry firms, by survey year and firm size.

Region	Total sample (n=5,216) ^z			SY2009 (n=2,259) ^z			SY2014 (n=1,747) ^z			SY2019 (n=1,210) ^z		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
Appalachian	146	393	186	53	121	84	45	120	67	48	51	35
Great Plains	25	70	27	12	21	11	6	36	9	7	13	7
Midwest	179	464	230	83	187	91	47	176	86	49	101	53
Mountain	41	81	60	22	34	24	10	29	19	9	18	17
Northeast	284	616	231	121	236	111	97	257	73	66	123	47
Pacific	118	295	259	55	149	138	24	58	58	39	88	63
Southcentral	59	209	105	29	86	37	23	66	34	7	57	34
Southeast	223	654	361	104	280	169	37	243	127	82	131	65

^zFirm size was estimated using reported annual sales amounts. The small firms reported annual sales from \$10,000 to \$124,999. Medium sized firms reported annual sales between \$125,000 and \$749,999. The large firms reported annual sales equal to or above \$750,000.

Table 4. Percent of annual sales attributed to different ornamental plant types, by survey year.

Plant Type	Total sample %	SY2009 %	SY2014 %	SY2019 %	Significance ^z
Deciduous trees	10.9	13.0	9.4	9.0	ab
Deciduous shrubs	4.8	5.1	4.7	4.5	
Broad-leaved evergreen shrubs	5.7	6.5	4.9	5.3	a
Narrow-leaved evergreen shrubs	2.6	2.9	2.3	2.5	
Evergreen trees	8.6	11.1	6.3	7.1	ab
Vines	2.2	2.1	2.1	2.5	
Roses	1.7	1.7	1.8	1.5	
Herbaceous Perennials	8.5	7.4	9.6	9.0	a
Flowering annuals	10.6	8.3	12.6	11.9	ab
Other annuals (vegetables, fruits, and herbs)	6.8	4.8	8.2	8.5	ab
Flowering potted plants	5.8	5.2	6.0	6.7	b
Christmas trees	4.8	5.7	4.9	3.0	ab
Fruit trees	2.6	2.1	3.0	3.3	b
Foliage (indoor, outdoor)	3.8	4.0	3.2	4.1	
Turfgrass sod	1.6	2.4	1.1	0.8	ab
Propagative materials (liners, cuttings, plugs, etc.)	3.4	3.3	3.1	4.2	
Other plants ^y	9.4	9.2	9.3	9.9	
n	5,216	2,259	1,747	1,210	

^zSignificance was tested using ANOVA and Tukey's honest significance test, where a indicates significance between SY2009 and SY2014 at 5%, b indicates significance between SY2009 and SY2019 at 5%, and c indicates significance between SY2014 and SY2019 at 5%.

^yParticipants were able to write in plants for the "other plants" category. Several plant types were written in and included: ornamental grasses, palms, pineapple plants, aquatic plants, bamboo, orchids, bonsai, bromeliads, cut flowers, cacti and succulents, bulbs, and so forth.

sized firms generate sales through more herbaceous species (e.g., herbaceous perennials, other annuals (vegetables, fruits, herbs), flowering potted plants) and specialty niche plants (e.g., Christmas trees, other plants). Similar trends were observed across the survey years, suggesting stability of this trend across time. These results imply that larger firms offer a greater diversity of plant types rather than concentrating on a single species or type of plant. Great

diversity in product offerings would reduce the percent of sales attributed to each plant type, although the total plant sales would be higher than the small- or medium-sized firms given that firm size was based on annual sales.

Different production methods used by green industry firms were also collected. Tables 6 and 7 show the proportion of firms that indicated a portion of their sales came from each of the production methods. The majority

Table 5. Percent of annual sales attributed to different ornamental plant types, by survey year and firm size.

Plant Type	Total sample (n=5,216) ^z				SY2009 (n=2,259) ^z			SY2014 (n=1,747) ^z			SY2019 (n=1,210) ^z					
	Small %	Medium %	Large %		Small %	Medium %	Large %	Small %	Medium %	Large %	Small %	Medium %	Large %			
Deciduous trees	9.0	10.6	12.6	bc	11.5	12.4	15.1	bc	7.2	9.7	10.2	6.9	8.9	11.1	b	
Deciduous shrubs	3.9	4.6	5.8	bc	4.3	5.0	5.7		2.8	4.6	6.1	bc	4.3	3.9	5.6	
Broad-leaved evergreen shrubs	4.1	5.4	7.5	abc	4.2	6.4	8.3	abc	3.2	4.2	7.5	bc	4.6	5.4	5.8	
Narrow-leaved evergreen shrubs	1.9	2.6	3.1	b	2.4	2.8	3.4		1.7	2.4	2.5		1.4	2.6	3.5	
Evergreen trees	9.5	8.7	7.7		12.3	11.8	9.2		7.6	6.3	5.6		6.8	7.1	7.6	
Vines	1.4	2.1	2.9	bc	1.2	2.1	2.6	b	1.5	1.8	3.1	bc	1.7	2.6	3.2	
Roses	0.9	1.6	2.4	abc	0.8	1.6	2.6	bc	1.2	1.8	2.2		0.9	1.2	2.5	bc
Herb. Perennials	9.7	9.0	6.8	bc	8.7	7.6	6.1		9.1	10.8	7.4	c	11.8	8.5	7.3	b
Flowering annuals	11.3	10.6	10.1		9.6	7.8	8.3		13.8	12.6	12.1		11.4	12.7	10.8	
Other annuals (vegetables, fruits, and herbs)	8.9	7.5	4.1	bc	7.4	4.8	3.0	abc	10.1	9.2	5.1	bc	10.0	9.7	5.0	bc
Flowering potted plants	7.5	5.6	5.0	ab	4.9	5.5	4.9		9.7	5.2	5.2	ab	9.3	6.3	4.9	b
Christmas trees	7.2	5.3	2.1	abc	8.9	6.6	2.0	bc	7.1	5.3	2.5	bc	4.6	2.9	1.6	b
Fruit trees	2.3	2.8	2.7		1.8	2.1	2.3		2.1	3.1	3.2		3.4	3.4	2.8	
Foliage (indoor, outdoor)	2.4	3.3	5.5	bc	2.0	4.0	5.5	b	2.7	2.5	5.0	c	2.9	3.4	6.5	bc
Turfgrass sod	0.3	1.2	3.3	bc	0.6	2.5	3.7	ab	0.1	0.3	3.3	bc	0.1	0.3	2.5	bc
Propagative materials (liners, cuttings, plugs, etc.)	3.5	3.4	3.4		3.1	3.4	3.1		3.2	3.1	3.0		4.6	3.8	4.7	
Other plants ^y	10.9	9.9	7.3	bc	11.3	9.4	7.2	b	10.1	9.8	7.7		11.0	11.0	7.0	

^zFirm size was estimated using reported annual sales amounts. The small firms reported annual sales from \$10,000 to \$124,999. Medium sized firms reported annual sales between \$125,000 and \$749,999. The large firms reported annual sales equal to or above \$750,000. Significance was tested using ANOVA and Tukey's honest significance test where a indicates significance between small and medium sized firms at 5%, b indicates significance between small and large sized firms at 5%, and c indicates significance between medium and large sized firms at 5%.

^yParticipants were able to write in plants for the "other plants" category. Several plant types were written in and included: ornamental grasses, palms, pineapple plants, aquatic plants, bamboo, orchids, bonsai, bromeliads, cut flowers, cacti and succulents, bulbs, and so forth.

Table 6. Percent of firms that indicated a percent of their annual sales came from specific production methods, by survey year.

	Total Sample %	SY2009 %	SY2014 %	SY2019 %	Significance ^z
Above-ground container production	73.3	70.0	75.8	76.0	ab
Balled and burlapped	27.8	33.5	25.9	19.8	abc
Field-grown bags	3.2	4.1	2.2	3.2	a
Bare root	13.7	13.5	13.9	13.5	
Balled and potted / process balled ^y	3.9	4.9	3.0	3.2	ab
In-ground containers / pot in pot	5.4	5.3	5.6	5.5	
Other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.)	14.0	13.9	15.2	12.3	
n	5,216	2,259	1,747	1,210	

^zThe mean proportion of firms was estimated by firms who stated >0% equaled 1 while those indicating missing values or 0% were assigned a 0. Significance was tested using ANOVA and Tukey's honest significance test where a indicates significance between SY2009 and SY2014 at 5%, b indicates significance between SY2009 and SY2019 at 5%, and c indicates significance between SY2014 and SY2019 at 5%.

^yBalled and potted / processed balled refers to a dormant plant that is dug and the media around the root mass is balled. The plant is then placed in a container for the balled and potted or is sold without a container for the process balled production method.

of the total sample (73.3%) indicated a proportion of their sales came from above-ground container production, followed by balled and burlapped plants, other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.), and bare root. Field-grown bags, balled and potted, and in-ground containers/pot in pot were selected less frequently. Relative to 2009, a larger proportion of participants in the 2014 and 2019 surveys indicated a portion of sales came from above-ground container production while fewer participants indicated sales from balled and potted plants. Balled and burlapped plants were produced more frequently by the 2009 survey participants than those in subsequent data collection events. Additionally, a higher proportion of participants in 2009 indicated that field-grown bag plants contributed to their sales than those in 2014. If firm size is taken into consideration (Table 7), larger firms tend to indicate sales attributed to above-ground container production and balled and burlapped plants. Larger firms also had a higher prevalence of in-ground containers/pot in pot in the 2009 and 2019 survey years that contributed to sales. Large firms exhibited a higher proportion of sales from balled and potted plants when compared to medium-sized

firms for the 2009 and 2019 surveys. In the 2019 survey, a higher proportion of small firms sold bare root products relative to large firms. In 2009, a higher proportion of small firms indicated other production methods relative to medium- and large-sized firms.

The proportion of annual sales attributed to the different production methods followed similar trends to the proportion of firms selling the plants grown using the different production methods (Tables 8–9). In total, participants indicated 61.5% of their annual sales came from above-ground container production plant sales, followed by balled and burlapped plant sales (13.2%), other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.) (8.9%), and bare root sales (6.1%; Table 8). Less than 2% of annual sales were attributed to in-ground containers/pot in pot, balled and potted, and field-grown bag plants. Several differences were noted across the survey years. Participants in the 2009 survey attributed a lower percentage of sales to above-ground container production plants than participants in the 2014 or 2019 surveys. Conversely, 2009 participants attributed a higher percentage of sales to plants grown using balled and burlapped or balled and

Table 7. Percent of U.S. Green Industry firms that sold different ornamental plant production methods, by survey year and firm size.

	Total sample (n=5,216) ^z			SY2009 (n=2,259) ^z			SY2014 (n=1,747) ^z			SY2019 (n=1,210) ^z		
	Small %	Medium %	Large %	Small %	Medium %	Large %	Small %	Medium %	Large %	Small %	Medium %	Large %
Above-ground container production	69.9	71.4	79.4	bc	65.0	68.0	77.0	bc	70.6	73.3	84.4	bc
Balled and burlapped	22.5	25.9	35.2	bc	30.6	32.3	37.4	b	19.4	23.7	34.7	bc
Field-grown bags	3.3	2.7	4.1	c	4.8	2.9	5.6	c	2.1	2.1	2.3	
Bare root	13.9	13.7	13.4		12.3	12.9	15.5		13.5	14.5	12.9	
Balled and potted / process balled ^y	3.8	3.2	5.2	c	5.0	3.9	6.5	c	2.4	3.1	3.2	
In-ground containers / pot in pot	4.2	4.3	8.6	bc	4.6	3.7	8.6	bc	4.2	4.9	7.8	
Other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.)	15.3	14.6	11.9	bc	16.3	15.2	10.1	bc	17.6	15.3	13.5	

^zFirm size was estimated using reported annual sales amounts. The small firms reported annual sales from \$10,000 to \$124,999. Medium sized firms reported annual sales between \$125,000 and \$749,999. The large firms reported annual sales equal to or above \$750,000. Significance was tested using ANOVA and Tukey's honest significance test where a indicates significance between small and medium sized firms at 5%, b indicates significance between small and large sized firms at 5%, and c indicates significance between medium and large sized firms at 5%.

^yBalled and potted / processed balled refers to a dormant plant that is dug and the media around the root mass is balled. The plant is then placed in a container for the balled and potted or is sold without a container for the process balled production method.

Table 8. Percent of annual sales attributed to different production methods, by survey year.

Product Form	Total %	SY2009 %	SY2014 %	SY2019 %	Significance ^z
Above-ground container production	61.5	57.1	64.3	65.7	ab
Balled and burlapped	13.2	17.1	11.1	8.9	ab
Other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.)	8.9	9.0	9.7	7.6	
Bare root	6.1	5.9	6.1	6.6	
In-ground containers / pot in pot	1.7	1.6	1.8	1.9	
Balled and potted / process balled ^y	1.2	1.7	0.8	0.8	ab
Field-grown bags	0.9	1.2	0.4	1.1	ac
n	5,216	2,259	1,747	1,210	

^zSignificance was tested using ANOVA and Tukey's honest significance test where a indicates significance between SY2009 and SY2014 at 5%, b indicates significance between SY2009 and SY2019 at 5%, and c indicates significance between SY2014 and SY2019 at 5%.

^yBalled and potted / processed balled refers to a dormant plant that is dug and the media around the root mass is balled. The plant is then placed in a container for the balled and potted or is sold without a container for the process balled production method.

potted production methods than participants in the 2014 or 2019 surveys. Participants in the 2014 survey attributed a lower percentage of sales to field-grown bags relative to participants in the 2009 and 2019 surveys. The magnitude of sales attributed to the different production methods was highest for the above-ground container production, balled and burlapped, and other production methods, but it varied by year and firm size (Table 9). The proportion of sales attributed to above-ground container production products was higher for large-sized firms compared to small-sized firms in the 2009 survey and when compared to the small- and medium-sized firms in the 2014 survey. A larger percent of sales were attributed to balled and burlapped production methods for large-sized firms relative to small sized firms in the 2019 survey. The increased use of both the above-ground container and balled and burlapped production methods among large-sized firms coincides with increased sales attributed to larger plants that would likely be grown using these methods (e.g., deciduous trees, broad-leaved evergreen shrubs, etc. (Table 7)). Small-sized firms had more sales attributed to other types of production methods relative to large-sized firms in the 2009 and 2014 surveys. Medium-sized firms also had more sales in other types of production methods than large-sized firms in the 2009

survey. These differences may reflect that small- and medium-sized firms attribute a fair portion of their annual sales to herbaceous plants (e.g., herbaceous perennials, other plants (vegetables, fruits, herbs)) and specialty items (e.g., Christmas trees) than large-sized firms and that these products may require different production methods to produce, package and sell them.

Integrated pest management (IPM) strategies used by U.S. green industry firms were also surveyed (Table 10). The most frequently used IPM strategy was removal of infested plants (employed by 81% of participating firms), followed by cultivation/hand weeding (nearly 70% of firms), spot treatment with pesticides (66%), alternating pesticides (56%), inspecting incoming stock (56%), and elevating or spacing plants (55%). Other IPM strategies exhibited lower participation percentages, which may be due to the fact that they were not necessarily compatible with all operations. For instance, 41 percent of firms indicated ventilating greenhouses (a strategy that is irrelevant for firms without greenhouses). IPM strategies selected by less than 10 percent of participating firms were sanitizing water foot baths, retention pond water treatment, soil solarization/sterilization, and screening barriers to prevent pest entry.

Table 9. Percent of annual sales attributed to different production methods, by survey year and firm size.

	Total sample (n=5,216)				SY2009 (n=2,259)				SY2014 (n=1,747)				SY2019 (n=1,210)		
	Small	Medium	Large		Small	Medium	Large		Small	Medium	Large		Small	Medium	Large
Above-ground container production	60.1	60.5	64.4	bc	54.3	55.9	60.9	b	61.7	62.6	69.6	bc	67.7	65.6	63.9
Balled and burlapped	11.4	13.3	14.3	b	15.6	17.6	17.5		9.5	11.3	11.6		6.4	8.6	12.0
Field-grown bags	0.8	0.9	1.0		1.3	1.0	1.4		0.2	0.4	0.5		0.7	1.4	0.8
Bare root	6.9	6.4	5.2		6.6	5.7	5.9		6.2	6.8	4.6		8.0	7.0	4.5
Balled and potted / process balled ^y	1.6	1.1	1.0		2.1	1.4	1.7		1.1	1.0	0.2		1.4	0.4	0.8
In-ground containers / pot in pot	2.2	1.5	1.8		1.9	1.2	1.9		2.7	1.6	1.6		2.1	2.0	1.7
Other types (e.g., cut trees, budwood, scions, seeds, tissue cultured plantlets, unrooted cuttings, etc.)	10.2	9.6	6.7	bc	10.5	10.5	5.4	bc	12.5	9.8	7.8	b	7.5	7.6	7.9

^zFirm size was estimated using reported annual sales amounts. The small firms reported annual sales from \$10,000 to \$124,999. Medium sized firms reported annual sales between \$125,000 and \$749,999. The large firms reported annual sales equal to or above \$750,000. Significance was tested using ANOVA and Tukey's honest significance test where a indicates significance between small and medium sized firms at 5%, b indicates significance between small and large sized firms at 5%, and c indicates significance between medium and large sized firms at 5%.

^yBalled and potted / processed balled refers to a dormant plant that is dug and the media around the root mass is balled. The plant is then placed in a container for the balled and potted or is sold without a container for the process balled production method.

Table 10. Percent of responding firms that participated in different integrated pest management (IPM) strategies, by survey year.

IPM Strategy	Total Sample %	SY2009 %	SY2014 %	SY2019 %	Significance
Remove infested plants	81.4	82.7	81.4	79.2	b
Alternate pesticides to avoid chemical resistance	56.1	61.2	51.2	53.7	ab
Elevate or space plants for air circulation	54.6	55.6	55.1	51.9	
Use cultivation, hand weeding	69.7	73.0	69.1	64.1	abc
Disinfect benches/ground cover	32.8	34.0	32.4	31.3	
Use sanitized water foot baths	2.6	2.6	2.1	3.5	
Soil solarization/sterilization	8.2	9.7	7.3	6.6	ab
Monitor pest populations with tarp or sticky boards	24.5	25.2	23.5	24.8	
Adjust pesticide application to protect beneficials	32.6	35.9	28.7	32.3	a
Use mulches to suppress weeds	34.8	35.3	37.5	29.9	bc
Beneficial insect identification	26.0	27.3	25.1	25.0	
Inspect incoming stock	55.6	57.0	53.9	55.5	
Manage irrigation to reduce pests	37.7	37.5	36.0	40.3	c
Spot treatment with pesticides	66.4	71.9	61.8	62.6	ab
Ventilate greenhouses	41.4	40.8	41.6	42.6	
Use beneficial insects	17.2	16.2	17.0	19.1	
Keep pest activity records	18.3	21.4	17.5	13.5	abc
Adjust fertilization rates	32.6	36.4	31.6	27.1	abc
Screening/barriers to exclude pests	9.5	9.5	9.4	9.8	
Use bio-pesticides/lower toxicity	17.6	17.7	17.3	17.6	
Treat retention pond water	3.9	4.6	3.6	2.8	b
Use pest resistant varieties	29.4	34.0	28.2	22.9	abc

^aSignificance was tested using ANOVA and Tukey's honest significance test where a indicates significance between SY2009 and SY2014 at 5%, b indicates significance between SY2009 and SY2019 at 5%, and c indicates significance between SY2014 and SY2019 at 5%.

The use of several different IPM strategies by U.S. green industry firms varied by survey year (Table 10). In general, participation in IPM strategies decreased in more recent survey years. To illustrate, cultivation and hand weeding were used by more firms in the 2009 survey than in the 2014 or 2019 surveys. A similar trend with decreasing use of adjusting fertilizer rates, pest resistant varieties, and keeping pest records occurred across survey years. Other strategies that were more commonly used by 2009 participants included alternating pesticides, spot treating with pesticides, and soil solarization/sterilization. The use of infested plant removal, mulches to suppress weeds, treatment of retention pond water, and adjusting pesticides to protect beneficial insects were less frequent in 2019 participating firms. Managing irrigation to reduce pests was used more frequently by 2019 participating firms than those who participated in the 2014 survey. Although insignificant, there were some upward trends that may be indicative of changing practices in the future. Specifically, the use of sanitizing water foot baths, greenhouse ventilation, and beneficial insects increased in firms surveyed in 2019 when compared to the previous surveys. These IPM strategies may become increasingly popular in upcoming years or may reflect shifting production practices and methods.

Differences in IPM strategies used by firm size and survey year were also explored (Table 11). Overall, as firm size increased, the firms' participation in IPM strategies increased regardless of the type of strategy or survey year. Interestingly, statistical differences between small- and medium-sized firms were infrequent, indicating similar levels of use; however, most IPM strategies were more frequently employed by large-sized firms when compared to small- or medium-sized firms. This observation may be due to several factors. Larger firms may need to use a combination of different methods to decrease pest control

costs and preventative measures for disease and pest pressures. The need to use a combination of different methods to prevent disease and pests may also be heightened in larger firms due to a larger volume of production and number of plant varieties/species produced. Both factors could result in increased pest and disease problems related to those specific crops. Additionally, producing different types of plants increases the number of different pests that could negatively impact production, meaning different IPM strategies may be required to more effectively reduce pest density. The only IPM strategies where medium-sized firms had a significantly greater level of use than small-sized firms included the following: using alternate pesticides to avoid chemical resistance, spot treatment with pesticides, inspection of incoming stock, and keeping pest activity records.

This report provides an overview of green industry production practices based on a national survey conducted in 2019. Access to up-to-date information such as this lies at the heart of solving many of the issues facing the environmental horticulture industry. This information should be of interest to the stakeholders, including nursery producers, landscape service firms, and retailers. Our findings are also important for crop service companies and Extension personnel, as they design and deliver practices and solutions for green industry firms. The environmental horticulture industry continues to be an important sector of the agricultural economy, providing economic value to local communities and the country as well as aesthetic beauty that is conducive to human psychological well-being and productivity. Understanding the key factors that influence the horticulture industry will help businesses to manage production risk more effectively and competitively position their operations in the complex marketplace.

Table 11. Percent of responding firms that participated in different integrated pest management (IPM) strategies, by year and firm size.

IPM Strategy	Total Sample ^z				SY2009 ^z				SY2014 ^z				SY2019 ^z			
	Small %	Medium %	Large %		Small %	Medium %	Large %		Small %	Medium %	Large %		Small %	Medium %	Large %	
Remove infested plants	80.3	80.3	84.4	bc	82.5	82.7	82.9		82.0	79.1	85.8	c	75.2	77.8	85.4	bc
Alternate pesticides to avoid chemical resistance	42.8	51.6	74.4	abc	47.9	57.7	76.7	abc	37.7	45.5	71.5	abc	39.4	50.2	73.8	abc
Elevate or space plants for air circulation	49.7	51.8	63.1	bc	49.8	53.4	63.3	bc	50.9	51.5	65.3	bc	48.5	49.5	59.5	bc
Use cultivation, hand weeding	65.1	68.6	74.9	bc	70.2	71.9	76.8	b	60.6	68.3	76.1	abc	61.2	62.9	69.2	
Disinfect benches/ground cover	27.7	28.2	45.2	bc	28.5	29.4	45.6	bc	27.7	27.7	45.0	bc	26.4	26.5	44.9	bc
Use sanitized water foot baths	1.3	1.3	6.1	bc	1.7	1.4	5.1	bc	1.0	0.9	5.3	bc	1.0	1.5	9.3	bc
Soil solarization/sterilization	7.2	7.0	10.9	bc	7.9	8.0	13.7	bc	6.9	7.2	7.8		6.5	5.0	9.7	c
Monitor pest populations with tarp or sticky boards	18.5	19.8	37.7	bc	18.5	20.4	38.2	bc	17.0	20.0	34.7	bc	19.9	18.4	41.1	bc
Adjust pesticide application to protect beneficials	25.7	28.5	45.3	bc	31.5	31.7	46.0	bc	21.1	25.1	40.8	bc	20.8	28.4	50.5	abc
Use mulches to suppress weeds	36.4	36.5	30.4	bc	37.1	37.3	30.5	c	38.4	39.2	33.4		33.6	30.4	25.5	
Beneficial insect identification	24.5	25.1	28.9	bc	25.2	26.8	29.8		21.8	24.7	27.9		26.1	22.5	28.7	
Inspect incoming stock	47.8	52.0	68.1	abc	47.5	53.8	69.2	abc	45.0	50.5	66.6	bc	50.8	51.0	68.2	bc
Manage irrigation to reduce pests	31.1	33.1	50.9	bc	29.8	33.0	50.7	bc	29.1	31.0	50.7	bc	35.2	36.9	51.4	bc
Spot treatment with pesticides	57.6	62.6	79.8	abc	62.3	70.2	81.7	abc	53.3	55.8	79.5	bc	54.4	59.3	76.3	bc
Ventilate greenhouses	38.0	37.8	50.7	bc	35.6	37.1	50.7	bc	38.8	37.8	51.2	bc	41.0	39.2	50.2	c
Use beneficial insects	16.4	15.8	20.2	bc	15.2	15.4	18.3		17.3	16.1	18.6		17.6	15.8	26.5	bc
Keep pest activity records	9.5	13.8	32.9	abc	11.3	16.5	37.0	abc	10.4	13.1	30.9	bc	5.9	9.8	27.4	bc
Adjust fertilization rates	27.0	28.3	44.8	bc	30.2	31.3	49.5	bc	26.0	27.7	43.1	bc	23.1	23.4	37.7	bc
Screening/barriers to exclude pests	9.2	8.3	12.1	bc	9.0	7.6	12.9	c	9.3	9.0	10.4		9.4	8.2	12.8	
Use bio-pesticides/lower toxicity	14.2	15.0	24.7	bc	14.2	15.2	24.5	bc	10.7	15.4	25.4	bc	17.6	14.1	24.0	c
Treat retention pond water	1.9	1.9	9.0	bc	1.9	2.4	10.2	bc	1.4	2.0	8.2	bc	2.3	0.5	7.5	bc
Use pest resistant varieties	27.0	26.6	36.5	bc	31.0	31.1	40.8	bc	26.6	25.6	34.5	bc	21.2	19.4	30.8	bc

^zFirm size was estimated using reported annual sales amounts. The small firms reported annual sales from \$10,000 to \$124,999. Medium sized firms reported annual sales between \$125,000 and \$749,999. The large firms reported annual sales equal to or above \$750,000. Significance was tested using ANOVA and Tukey's honest significance test where a indicates significance between small and medium sized firms at 5%, b indicates significance between small and large sized firms at 5%, and c indicates significance between medium and large sized firms at 5%.

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