rows, preventing seeding, preemergence weed barrier, flame thrower, heat, clean buffer areas, and cultivation by mules were also reported.

Use of the six major weed control alternatives showed about the same distribution over the four regions (Table 6). The only alternatives rated as very effective by more than half the respondents were in the western region—media sterilization by steam (59%) and tractor cultivation (52%) (results not shown). A slightly higher use of solarization was reported in the southeastern region (4% to 12%) than the other three regions. However, there was not much agreement among respondents from different regions on the effectiveness of soil solarization. For example, 19% to 40% of the respondents found it very effective and 5% to 23% found it ineffective (results not shown).

Nonchemical weed control alternatives tended to be used more by small firms than medium or large firms. The maximum number of respondents from small, medium, or large firms that used an alternative was 265, 227, and 165, respectively. However, the number of respondents who used a specific alternative varied considerably by firm size (results not shown). Use of handweeding, tractor cultivation, and mulching were not affected by firm size, with trends similar to those nationwide (Table 5). In contrast, small firms reported slightly more (15% to 18%) use of mowing and substantially more use of media sterilization (94% vs. 38% and 35% for medium and large firms, respectively) and solarization (64% vs. 24% and 21% for medium and large firms, respectively) for weed control. Interestingly though, 41% of respondents from large firms rated solarization as very effective but only 30% of respondents from small firms rated it very effective (Table 7). The relatively high use of media sterilization and solarization by small firms may have been because a large proportion of respondents from small firms were involved with container or greenhouse production. Many medium and large firms resorted to the other four methods as alternatives to chemical weed control, although those that used media sterilization and soil solarization were generally as satisfied (i.e., somewhat effective plus very effective) with these methods as the small firms (Table 7).

Implications for university research and extension programs

University faculty should consider initially targeting large firms in their research and extension programs because this would seem to have the greatest initial impact. Since large firms were the greatest consumers of herbicides, significant reductions in total herbicide use could be realized if large firms increased their use of nonchemical alternatives, or reduced their chemical utilization by using current herbicides more effectively and by applying herbicides that are effective at lower

rates of active ingredients. Moreover, larger firms have more resources available to invest in experimenting with new or modified weed control practices. Incentives to growers on a local, state, or national level would further encourage use of alternative practices or more effective herbicides.

Based on the results of this survey, specific areas of weed control research that could be addressed are the following: 1) reduction in overall use of glyphosate through use of herbicidal soaps or nonchemical alternatives, 2) finding alternatives for herbicides that pose a relatively high risk of contaminating groundwater, and 3) nonchemical alternatives, especially for practices like soil solarization. Almost 30% of respondents from large firms rated this practice as effective but impractical. However, refinement of this technique could greatly increase its use by the greenhouse and nursery industry.

Follow-up surveys need to be conducted so that more specifics can be obtained about weed control practices. For example, detailed information about frequency of weed control practices and rates used could be procured by interviewing growers individually. This was one of the issues that we were unable to address in this survey because growers were asked to provide information about all of their pest control practices. In the interest of obtaining a high response rate, we had to limit the amount of information we could ask for with regard to chemical pesticide use (herbicides, insecticides/acaricides, fungicides/bactericides, fumigants, and plant growth regulators) and nonchemical alternatives.

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Pest Management in the United States Greenhouse and Nursery Industry: V. Insect and Mite Control

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Summary. A national survey of the greenhouse and nursery industry provided data on insecticide/miticide use in 1993. Respondents reported using 46 different compounds, and the industry used an estimated 2.8 million pounds of active ingredients to control insect and mite pests. The most frequently used material

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was acephate: 52% of the respondents reporting use in 1993. The most heavily used material was a miticide, dienochlor, with an estimated 643,281 lb (292,400 kg) applied, or 28% of the total. Only three other compounds represented more than 5% of the total use—carbaryl (498,073 lb or 22%) (226,397 kg), diazinon (326,131 lb or 14%) (148,242 kg), and propargite (143,888 lb or 6%) (65,404 kg). Of the top four products, two (dienochlor and propargite) are miticides. Together these represented 34% of the total estimated insecticide/miticide use, demonstrating the importance of mites as pests in the industry.

The intensive nature of production and high aesthetic value of greenhouse and nursery crops make pest control an important economic issue. In pursuit of totally pest-free plant materials, the ornamentals industry has become heavily dependent on pesticides. Pesticide costs can be a major expense for nurseries, many of which are small, family-run operations. In 1992, SRI International produced a survey of ornamental growers in the United States, which evaluated the most commonly used products for pest control. They found that insecticides/miticides accounted for 42% of the chemicals used (compared to 38%, 18%, and 0.5% for the fungicides/bactericides, herbicides and growth regulators used, respectively).

The views of producers and consumers of ornamentals concerning pest management are changing rapidly in response to concerns about pesticide use. Much attention has been focused on the potential for damage to the ozone layer (Pardo, 1995) and groundwater (Keese et al., 1992) from the inappropriate use of chemicals in agriculture in general. Unfortunately, these changes often have not been accompanied by a change in tolerance for the pests targeted by the pesticides in question. Producers must respond to the concern over pesticide use and simultaneous demand for pest-free plants. Although the use of such earth-friendly compounds as horticultural oils (King, 1993), insect growth regulators (IGRs) (Oetting, 1994), and hot pepper wax (Chadwick, 1994) has increased, often as part of an integrated pest management (IPM) program, chemical pesticides continue to be the primary pest control method for the industry.

Many professionals can report observational shifts in use of specific pest control methods, but this is the first comprehensive national study on insect control methods used by the greenhouse and nursery industries in the United States. The objectives of the study were to document the level of chemical pesticide use and the industry experience with nonchemical control measures.

This survey was conducted and data were analyzed as detailed previously by Garber et al. (1996).

Results and discussion

Chemical insect/mite control. Respondents listed 46 different compounds used as insecticides/miticides. The chemical reported with

the highest frequency of use was acephate (Orthene), which was used by 52% of the respondents applying an estimated 106,382 lb (48,356 kg) active ingredient (a.i.) (Table 1). The chemical insecticide/miticide that accounted for the most pounds of active ingredient used was dienochlor (Pentac) with a total of 643,281 lb (292,400 kg) a.i. (27% usage). Other chemicals with large amounts of active ingredient applied were carbaryl (Sevin) (31% and 498,073 lb a.i.) (226,397 kg) and diazinon (38% of the respondents and 326,131 lb a.i.) (148,242 kg). Twenty chemicals listed as "other", were each used by less than 1% of the respondents. There are very large differences in use rate, measured as amount of ai per application, between older chemicals such as chlorinated hydrocarbons, organo-phosphates and carbamates, and newer materials like the pyrethroids and others. These differences suggest that the percent of respondents using a material may be a better indicator of the importance to the industry than total pounds ai applied. For example, the use rate for dienochlor is 4 to 8 oz a.i. per 100 gallons of spray mix, so the 643,281 pounds (292,400 kg) used nationwide translates to about 1.3 to 2.6 million 100-gal applications. By comparison, abamectin is mixed at a rate of 0.075 to 0.15 oz a.i. per 100 gallons, so the 5965 pounds (2711 kg) a.i. translates to about 0.6 to 1.3 million applications. In other words, it requires more than 100 times the active ingredient to make about twice as many applications.

The type of pest targeted for control by each chemical insecticide/miticide provides an indication of which pests were most important to orna-

Table 1. Estimated total insecticide use in the United States greenhouse and nursery industry.

Insecticide	Respondents		Amount (lb)	
	No.	% ²	Estimated total active ingredient (lb) ¹	%
Dienochlor	187	27	643281	28
Carbaryl	218	31	498073	22
Diazinon	264	38	326131	14
Propargite	25	4	143888	6
Chlorpyrifos	244	35	106434	5
Acephate	366	52	106382	5
Fluvalinate	199	28	79777	4
Endosulfan	99	14	79391	4
Fenpropathrin	78	11	75357	3
Malathion	41	6	35097	2
Lindane	108	15	28976	1
Bendiocarb	59	8	28047	1
Bifenthrin	204	29	19818	1
Dicofol	23	3	19649	1
Dimethoate	137	20	18712	1
Abamectin	217	31	5965	<1
Cyfluthrin	92	13	4719	<1
Other ^x	109	16	30177	2

¹Number of users for each chemical expressed as the percentage of respondents from the respective region.

²Use for respondents expanded to total estimated use using USDA total sales for greenhouse and nursery industry; ratio of respondents sales to USDA sales used to estimate total use.

^xIncludes Aldicarb, Azinphos-methyl, Dibrom, Fenamiphos, Fenbutatin, Formetanate, Hydramethylnon, Isazofos, Isofenphos, Lambda cyhalothrin, Methidathion, Methiocarb, Methomyl, Methoxy carb, Oxydemeton, Oxamyl, Oxythioquinox, Permethrin, Phosmet, and Trichlorfon.

Table 2. Pesticide usage for different type of pests.

Insecticide/miticide	Percent active ingredient (% response)			
	Wood-boring	Foliage feeding ²	Sucking pests ³	Soil-borne ⁴
Dienochlor	0.0	4.9	95.0	0.1
Carbaryl	0.1	96.0	3.8	0.1
Diazinon	0.6	20.6	61.7	17.1
Propargite	0.0	45.5	54.5	0.0
Chlorpyrifos	18.2	24.5	16.5	40.8
Acephate	1.3	55.4	36.6	6.7
Fluvalinate	0.8	55.7	43.2	0.3
Endosulfan	3.0	80.8	15.3	0.9
Fenpropathrin	0.0	89.0	11.0	0.0
Malathion	0.0	46.9	50.1	3.0
Lindane	76.3	6.0	11.2	6.5
Bendiocarb	0.7	8.7	4.3	86.3
Bifenthrin	0.4	40.6	56.8	2.2
Dicofol	0.0	1.2	98.8	0.0
Dimethoate	30.8	28.7	40.3	0.2
Abamectin	0.0	37.5	62.5	0.0
Cyfluthrin	0.2	25.8	72.6	1.4

²Includes beetles, caterpillars, leafminers.

³Includes scales, aphids, mites, lacebugs, stinkbugs, leafhoppers, thrips.

⁴Includes whitegrubs, black vine weevil larvae, fungus gnats, nematodes.

mentals producers in the United States. Of the 17 chemicals listed as used by at least 10% of respondents and/or with more than 20,000 pounds (9,091 kg) a.i. applied, three are primarily or exclusively used as miticides—dienochlor, propargite, and dicofol (Kelthane)—and four others—bifenthrin (Capture), abamectin, fluvalinate (Mavrik, Spur), and fenpropathrin (Danitol)—see major use to control mites. Acephate and diazinon were used for all types of pests, with the greatest use in control of foliage feeding and sucking pests (Table 2). Chlorpyrifos (Dursban) showed a broader range of application, with high levels of use in all four pest target groups. Carbaryl was used primarily for control of foliage-feeding pests. Wood-boring pests were controlled mainly with lindane and chlorpyrifos whereas soil-borne pests were controlled with diazinon, chlorpyrifos, and bendiocarb (Turcam). Most chemicals applied by the respondents were used on the foliage to control sucking pests (Table 3). This is not surprising, since this category included the major pests of greenhouse and nursery production—aphids,

mites, thrips, and whiteflies.

Analysis of variance performed for the 17 chemicals in Table 1 did not detect any statistically significant differences among the regions in amount of active ingredient used. Firms size likewise had no significant effect on use, except that acephate was used significantly more by large firms than by small or medium firms (F test, $P < 0.01$) (Table 4). Acephate was the most frequently reported for all regions. Diazinon was second most frequently used for all regions except the northeastern United States.

Alternatives to chemical insecticides

Responses to the Alternatives to Insecticides section were summarized as effective if the response was somewhat effective or very effective (Table 5). We also asked respondents to list other methods we may not have included in the questionnaire. Responses included pesticide-like methods (food grade peroxide, sabadilla dust, pesticide rotation, and spot spray), cultural methods (proper fertilization, irrigation timing, roguing, and water spray), physical methods (air movement and burning), and biological methods (predators, pheromone

traps, bait crop, and fish).

Most respondents reported using several different types of alternatives or adjuncts (e.g., scouting) to pesticides. The pesticide-like methods—*Bacillus thuringiensis* (Bt), insect growth regulators, horticultural oils, and insecticidal soaps were used by 48.0%, 33.4%, 60.6%, and 54.9% of the respondents, respectively (Table 5). These products were viewed as effective by 84% to 94% of the firms trying them. The extensive use of pesticide-like products may be the result of easy integration into a system accustomed to applying chemical pesticides. Cultural methods are more diverse in type and ease of use, and this is reflected in the number of respondents using each method (10% to 90%) and their reported efficacy (62% to 97%). Monitoring/scouting was used by almost 90% of the respondents with 97% efficacy. Sanitation was the next most popular with 85.4% use rate and 97.2% efficacy. The least used cultural method was reflective mulches at 10.2%, although 61.5% of these respondents reported it as effective. Isolation and reflective mulches were judged to be effective but impractical by 16.2%

Table 3. Total insecticide/miticide use for four categories of pests.

Pest	Amount		Frequency	
	Active ingredient (lb)	% of total	No. of respondents	% ²
Wood-boring	79110	2.4	298	7.3
Foliage feeding ³	1581930	47.0	1433	34.9
Sucking pests ⁴	1486765	44.1	1961	47.8
Soil-borne ⁵	217421	6.5	412	10.0
Total	3365225	100.0	4104	100.0

²Calculated as the total number of users in each category divided by total users of insecticide; some totals exceed number of respondents in survey due to use of more than one insecticide/miticide by some respondents.

³Includes beetles, caterpillars, leafminers.

⁴Includes scales, aphids, mites, lacebugs, stinkbugs, leafhoppers, thrips.

⁵Includes whitegrubs, black vine weevil larvae, fungus gnats, nematodes.

Table 4. Insecticide/miticide usage by region of the United States.

Insecticide/miticide	Region							
	Northeastern		Southeastern		North-central		Western	
	No. ^y	% ^z	No.	%	No.	%	No.	%
Dienochlor	37	25.9	50	24.0	55	25.7	45	34.6
Carbaryl	67	46.9	64	30.6	66	30.8	21	16.2
Diazinon	47	32.9	73	35.0	77	36.0	67	51.5
Propargite	6	4.2	9	4.3	4	1.9	6	4.6
Chlorpyrifos	39	27.3	83	40.0	74	34.6	48	36.9
Acephate	81	56.6	105	50.2	84	39.3	96	73.8
Fluvalinate	44	30.8	46	22.0	46	21.5	63	48.5
Endosulfan	19	13.3	25	12.0	27	12.6	28	21.5
Fenpropathrin	14	9.8	24	11.5	26	12.1	14	10.8
Malathion	12	8.4	6	2.9	14	6.5	9	6.9
Lindane	30	21.0	35	16.7	33	15.4	10	8.5
Bendiocarb	0	0.0	0	0.0	23	10.7	18	13.8
Bifenthrin	45	31.5	61	29.2	69	32.2	29	22.3
Dicofol	10	7.0	7	3.3	3	1.4	3	2.3
Dimethoate	31	21.7	44	21.1	39	18.2	23	17.7
Abamectin	42	29.4	55	26.3	56	26.2	64	49.2
Cyfluthrin	19	13.3	22	10.5	26	12.1	25	19.2

^zTable in descending order of number of respondents.

^yNumber of respondents using the insecticide as a percentage of respondents indicating residence in this region. Total for each region exceeds 100 because of multiple usage by most respondents.

and 12.3% of respondents, respectively (Table 5). Physical methods showed the same degree of diversity in use and effectiveness as cultural methods. Pruning was used by the most respondents (72%); 82.5% reported it as effective. In contrast, less than 25% of respondents used exclusion, and an equal

number reported it as effective but impractical. Effective exclusion techniques (primarily screening of some type) necessarily interfere with the kind of free access to production facilities required by an active ornamentals producer. Media sterilization was used by one-third of the respondents and was felt to be

highly effective. In all likelihood, media sterilization is not much needed in operations producing container plants where use of soilless potting media is quite common. Additionally, as reflected in the use of insecticide/miticides for soilborne pests, this is not as serious a concern for insect and mite control

Table 5. Frequency and effectiveness of insect/mite control alternatives in the United States greenhouse and nursery industry.

Alternative control	Respondents		Effectiveness (% reporting use)		
	No.	% reporting use	Not effective	Effective	Effective but impractical
Pesticide-like methods					
B.T. (Dipel, Thuricide, Gnatrol, etc.)	660	48.0	6.3	92.8	0.9
Insect growth regulators (Enstar II, Azatin, Margosan-O)	647	33.4	5.6	93.0	1.4
Horticultural oils (SAF-T-CIDE, Sunspray)	662	60.6	4.0	94.0	2.0
Insecticidal soaps (Impede)	649	54.9	13.5	83.7	2.8
Cultural methods					
Resistant varieties	646	64.6	4.6	90.4	5.0
Crop rotation	660	61.2	8.9	84.2	6.9
Sanitation	669	85.4	1.4	97.2	1.4
Reflective mulches	636	10.2	26.2	61.5	12.3
Isolation	644	41.1	8.7	75.1	16.2
Monitoring/scouting	668	89.8	1.7	97.0	1.3
Sticky cards	647	51.6	12.0	85.0	3.0
Physical methods					
Media sterilization (steam, solarization)	647	33.1	5.1	84.2	10.7
Pruning	651	72.4	13.0	82.5	4.5
Exclusion (netting, screening)	639	24.9	12.5	62.5	25.0
Biological methods					
Nematodes (Biosafe, Vector)	652	48.0	21.2	75.4	3.4
Parasitic wasps	642	8.7	26.8	66.1	7.1
Predatory mites	642	9.7	25.8	67.7	6.5

Table 6. Regional use of insect/mite control alternatives.

Alternative control	% reporting as effective ²			
	Region			
	Northeastern	Southeastern	North-central	Western
Pesticide-like methods				
B.T. (Dipel, Thuricide, Gnatrol, etc.)	41.7	50.8	42.2	58.7
Insect growth regulators (Enstar II, Azatin, Margosan-O)	29.2	36.5	27.7	42.1
Horticultural oils (SAF-T-CIDE, Sunspray)	69.7	61.0	54.6	56.9
Insecticidal soaps (Impede)	57.2	53.0	49.2	64
Cultural methods				
Resistant varieties	68.9	63.7	68.1	53.7
Crop rotation	62.2	63.0	64	53.2
Sanitation	83.9	83.9	85.4	89.8
Reflective mulches	9.7	7.3	7.5	20.2
Isolation	37.8	44.8	38.3	43
Monitoring/scouting	93.7	89.8	88.5	87.2
Sticky cards	47.4	48.3	47.5	66.9
Physical methods				
Media sterilization (steam, solarization)	35.3	30.6	28.8	41.9
Pruning	74.8	78.3	70.9	63.6
Exclusion (netting, screening)	25.5	21.5	26.1	27.5
Biological methods				
Nematodes (Biosafe, Exhibit)	19.6	11.0	13.3	35.5
Parasitic wasps	4.4	8.4	7.5	51.8
Predatory mites	5.1	11.2	8.5	15

²Combined response for somewhat effective and very effective ratings.

as for control of pathogens.

Finally, biological methods were the least used alternative control measures (Table 5). Nematode products such as Biosafe and Exhibit were used by almost 50% of the respondents: 21% reported

them as ineffective and 75% reported them as effective. Very few people (3% to 7%) reported these methods as effective but impractical, indicating the potential for this control tactic to fit well into the normal operations of an ornamental production

facility. The other two groups of biological control methods were parasitic wasps and predatory mites. Less than 10% of the respondents used either of these biological control agents. About two-thirds of those using these agents considered them effective.

Table 7. Proportion of respondent firms that have used various alternative insect/mite control tactics, reported as percentage of total in each category.

Control alternative	Firm size ²		
	Small	Medium	Large
Pesticide-like methods			
B.T. (Dipel, Thuricide, Gnatrol)	88.5	95.3	93.2
Insect growth regulators (Enstar II, Azatin, Margosan-O)	93.5	92.2	94.3
Horticultural oils (SAF-T-CIDE, Sunspray)	96.0	92.9	92.2
Insecticidal soaps (Impede)	82.4	81.1	87.5
Cultural methods			
Resistant varieties	95.7	89.1	83.7
Crop rotation	86.3	83.9	80.2
Sanitation	97.2	96.9	97.4
Reflective mulches	70.4	50.0	58.8
Isolation	80.4	72.2	71.4
Monitoring/scouting	95.6	98.1	98.0
Sticky cards	80.4	88.2	86.4
Physical methods			
Media sterilization	82.4	83.3	86.3
Pruning	85.2	83.4	76.6
Exclusion (netting, screening)	72.8	54.9	56.3
Biological methods			
Nematodes (Biosafe, Exhibit)	78.1	80.6	70.0
Parasitic wasps	78.5	57.1	64.3
Predatory mites	85.7	50.0	65.6

²Firm size based on 1993 sales: small (<\$500,000), medium (\$500,000–\$2,000,000) and large (>\$2,000,000).

Table 8. Experience with insect control alternatives by different size firms.

Control alternative	Experience (% response)								
	Not effective			Effective ²			Effective but impractical		
				Firm size					
	Small ³	Medium	Large	Small	Medium	Large	Small	Medium	Large
B.T. (Dipel, Thuricide, Gnatrol)	11.5	3.8	5.1	88.5	95.3	93.2	---	0.9	1.7
Nematodes (Biosafe, Exhibit, etc.)	18.8	16.7	26.0	78.1	80.6	70.0	3.1	2.8	4.0
Parasitic wasps	21.4	35.7	25.0	78.5	57.1	64.3	---	7.1	10.7
Insect growth regulators (Enstar II, Azatin, Margosan-O)	4.3	6.5	4.5	93.5	92.2	94.3	2.2	1.3	1.1
Predatory mites	14.3	35.7	28.7	85.7	50.0	65.6	---	14.3	6.3
Horticultural oils (SAF-T-CIDE, Sunspray)	2.6	5.6	4.3	96.0	92.9	92.2	1.3	1.6	3.5
Insecticidal soaps (Impede)	16.8	17.2	6.3	82.4	81.1	87.5	0.8	1.7	6.3
Resistant varieties	3.7	4.1	6.7	95.7	89.1	83.7	0.6	6.8	9.6
Media sterilization	5.9	5.2	4.5	82.4	83.3	86.3	11.8	11.5	9.1
Crop rotation	7.5	11.2	8.3	86.3	83.9	80.2	6.2	4.9	11.5
Pruning	10.9	14.6	14.0	85.2	83.4	76.6	4.0	1.9	9.3
Exclusion (netting, screening, etc.)	8.5	11.8	18.7	72.8	54.9	56.3	18.6	33.3	25.0
Sanitation	1.9	1.5	0.7	97.2	96.9	97.4	0.9	1.5	2.0
Reflective mulches	25.9	30.0	23.5	70.4	50.0	58.8	3.7	20.0	17.6
Isolation	9.3	7.8	9.1	80.4	72.2	71.4	10.3	20.0	19.5
Monitoring/scouting	2.2	0.9	2.0	95.6	98.1	98.0	2.2	0.9	---
Sticky cards	16.7	10.9	8.2	80.4	88.2	86.4	2.9	0.8	5.5

²Combined response for somewhat effective and very effective.

³Size of firm based on 1993 sales: small (\$0–\$500,000); medium (\$500,001–\$2,000,000) and large (>\$2,000,000).

Less than 10% of the respondents considered them impractical, despite problems with obtaining the predators or parasites and the necessary adjustments in other management practices.

Regional use of alternative insect and mite control measures revealed some differences across the United States. (Table 6). The methods falling in the pesticide-like category were used with about the same frequency by each region, as were most cultural methods. In contrast, the western region reported use of reflective mulches two to three times as frequently as the other regions. The western region also used sticky cards more frequently than the other three regions (Table 6). Pruning was used least by the respondents in the western region. The most dramatic differences in regional use of alternatives was seen for two of the biological methods. Parasitic wasps were reported as used by less than 10% of the respondents in the northeastern, southeastern, and north-central regions, but by just over 50% of the respondents in the western region. Predatory mites were used more or less equally by all four regions, but the western region used nematodes most commonly. The higher acceptance of biocontrol agents in the western region may be related to the climate and cultural conditions in the California location of a large portion of the western region respondents. Two other important factors are the leading role played by scientists in the Univ. of California system historically in identifying and developing protocols for the use of biocontrol agents, and the regulatory climate in California, which encourages and even requires the use of such alternatives.

Firm size also played a role in the use of

some types of alternatives to chemical insecticide/miticide. Use of Bt, insect growth regulators, and sticky cards increased slightly as firm size increased (Table 7). The perceived effectiveness of alternatives to chemical insect and mite control sometimes was related to firm size (Table 8). Small firms proved somewhat happier with use of resistant varieties, reflective mulches, isolation, and exclusion and were considerably more satisfied with using parasitic wasps and predatory mites than either medium or large firms.

Implications for university research and extension programs

Our results make it clear that mites are a major problem for producers of ornamental plants. This was true for all regions and across all firm sizes and types of production. Any program designed to change pesticide use patterns in the industry should focus on mite control as one of its major target areas. Some alternatives to the chemicals on our list are already available, and mites undoubtedly were the target of a significant portion of the horticultural oil and insecticidal soap applied in greenhouses and nurseries. Unfortunately, although we considered horticultural oils and insecticidal soaps as alternatives, current regulations include them as pesticides. As such they also are targeted for 50% reduction in use by the EPA and other regulatory agencies. This is an obvious flaw in the regulations, and must be corrected if we have any hope of reducing use of other insecticides by the targeted amount. Another important point that can be noted from these results is that

there will be a dramatic reduction in overall pesticide use, measured as pounds of active ingredient applied, as the industry moves from older chemistry to the newer, more active materials available today. Of the 2.8 million pounds of pesticide/miticide ingredients applied by the industry in 1993, three products—dienochlor (Pentac), carbaryl (Sevin), and diazinon—accounted for 64%. In the case of dienochlor, switching to a lower-use-rate miticide for mite control could result in a dramatic reduction in active ingredient applied for the same number of miticide applications. This, along with reclassification of soaps and oils, could make the goal of 50% reduction in pounds of pesticide applied quite reasonable for the industry.

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