Extension Education Methods

Reducing Insecticide Use in Home Gardens: Effects of Training and Volunteer Research on Adoption of Biological Control

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SUMMARY. More than 500 Master Gardeners in Indiana and Illinois were taught alternatives to the use of insecticides in workshops that focused on biological control of insect pests in home gardens. Gardeners also learned to conduct experiments in their backyards and were encouraged to participate in a summer research program

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that tested specific control methods. Workshop participants were surveyed before the workshop, and in two successive growing seasons to measure changes in their pest management practices. Overall, a significant percentage of gardeners stopped applying insecticides for up to two consecutive growing seasons after attending workshops. In addition, the adoption of biological control by participants appeared to be linked to their insecticide use and willingness to participate in the research process. A significant increase in the adoption of biological control was noted among garden researchers who did not use insecticides before the workshop or had reduced insecticide use following the workshop. No such change was noted for gardeners that did not conduct research. The relative contributions of workshop participation and hands-on research experience in pesticide reduction and biological control adoption are discussed.

Home gardens are frequently treated with pesticides, and in many areas, per-acre pesticide use in home gardens exceeds that of many agricultural commodities (Grieshop and Stiles, 1989; Whitmore et al., 1993). In addition to potential problems associated with pesticide applications, home gardeners also face related storage and disposal issues (Grieshop and Stiles, 1989). Further, U.S. Environmental Protection Agency (EPA) registration reviews following passage of the Food Quality Protection Act (FQPA) have reduced the number of pesticides available to homeowners. Use of commonly applied insecticides such as chlorpyrifos, dimethoate, diazinon and lindane has been cancelled for homeowners (EPA, 2003). Although reduced-risk insecti-

cides such as insecticidal soaps, horticultural oils, insect growth regulators and strains of *Bacillus thuringiensis* are exempt from FQPA mandated review, they account for only a small fraction of insecticides used by home gardeners (Braman et al., 1998).

Homeowners often treat pest symptoms without adequate information about the source of the problem, and often are unaware of alternatives to insecticides (Templeton et al., 1998). Furthermore, the limited availability of these alternatives (Latimer et al., 1996) and the lack of information about them contribute to their low rates of use (Alston and Reding, 1998; Braman et al., 1998). This is especially true for biological control which depends on the active conservation or augmentation of predators, pathogens and parasites (parasitoids) to kill pests. Successful implementation of biological control depends on adequate knowledge of how natural enemies control pests (Bambara and Orr, 2001). Unfamiliarity with the biology and efficacy of natural enemies leaves home gardeners unsure of how to use biological control as an alternative to insecticides (Van de Fliert, 1993).

Education and practical experience are keys to adoption of new technology (Decker et al., 1988; Strauss et al., 1991). Israel et al. (1999) showed that training workshops are more effective at influencing Master Gardeners than simply providing passive information such as publications. Participatory research is one way to give practical experience with new technologies. Although this approach has increased adoption rates of new technologies in a number of agricultural systems (Bentley 1994; Gerber 1992a, 1992b) it has not been widely used with home gardeners. Participatory research succeeds because it builds on the respective strengths of end-users, researchers and Extension educators (Bezdicheck and DePhelps 1994). To increase use of biological control in home gardens, educational programs should provide information on pesticide alternatives and the biology of natural enemies in active educational settings that encourage home gardeners to test these concepts in their gardens.

In this paper, we report how an education program on biological control of insects affected patterns of insecticide use and adoption rates of biological control by Master Garden-

Table 1. Garden experiments offered to participants during day-long training workshops on the principles and practices of biological control in home gardens between 1998 and 2002 in Indiana and Illinois.

Experiment	Crop	Studies completed by participants (no.)	Research question
Lacewing release	Cabbage (<i>Brassica oleracea</i>)	36	Does releasing lacewing (<i>Chrysoperla rufilabris</i>) eggs reduce damage by cabbage caterpillars?
Sugar spray	Cabbage	36	Can sugar water attract natural enemies of cabbage insect pests?
Floating rowcover	Zucchini (<i>Curcubita pepo</i>)	40	Do floating row covers help control squash insect pests?
Mechanical weed control	Snap bean (<i>Phaseolus vulgaris</i>)	46	Is weeding needed throughout the growing season?
Parasitic wasp release	Cabbage	52	Can releases of <i>Trichogramma pretiosum</i> control cabbage caterpillars?
Straw mulch	Potato (<i>Solanum tuberosum</i>)	36	Does straw mulch increase abundance of predators of colorado potato beetle (<i>Leptinotarsa decemlineata</i>)?
Nematode release	Iris (<i>Iris</i> spp.)	36	Can release of <i>Steinernema carpocapsae</i> control iris borer (<i>Macronoctua onusta</i>)?

[†]Imported cabbage worm (*Pieris rapae*), diamondback moth (*Plutella maculipennis*), and cabbage looper (*Trichoplusia ni*).

[‡]Cabbage caterpillars and cabbage aphid (*Brevicoryne brassicae*).

[§]Squash bug (*Anasa tristis*) and squash vine borer (*Melittia cucurbitaceae*).

ers in Indiana and Illinois. We worked with Master Gardeners because they are knowledgeable about pest management issues and they frequently volunteer to receive intensive training from extension specialists (Bobbitt, 1997). Further, because Master Gardeners serve to advise other home gardeners, we hoped to develop a cadre of individuals who could serve to educate others about alternatives to insecticides. Finally, we hope that our findings can be used by other extension programs to increase the use of biological control and reduce insecticide use in the home garden environment.

Materials and methods

EDUCATION PROGRAM. We trained 534 Master Gardeners during 16 one-day workshops held in nine locations in Indiana and Illinois between January and April from 1998–2002. The workshops focused two key aspects of biological control; its use as an alternative to insecticides in the home vegetable garden, and methods for testing its efficacy. We focused on insect pests of vegetables due to the ubiquity of home gardens the frequency of insect problems. We used lectures to illustrate concepts of insect pest management and natural enemy biology and diversity. Displays of both live and preserved specimens of natural enemies were used to show examples of natural enemies that can be found or purchased for use in the home garden. Each participant was given a notebook of training materials to reinforce basic concepts and

to help them identify natural enemies. From 1998–2000, we also provided a laminated set of cards with photographs of natural enemies and descriptions of their biology (Jeffords et al., 1997), a copy of the publication *Biological Control of Insects and Mites* (Mahr and Ridgway, 1993), and reprints of articles from *Biological Control News* (Mahr, 1998). In 2001–02, we provided a notebook of our slide presentation and the publication *Natural Enemies in your Garden: A Homeowner's Guide to Biological Control* (Lee and Landis, 2000). In 2001–02, to help identify pests and their natural enemies, we encouraged participants to use a Web-based guide that we produced (Heraux et al., 2002).

In the latter part of each workshop, we taught participants about the research process, how to design experiments, compare treatments and evaluate results. We proposed specific research questions on alternatives to insecticides to be addressed in their gardens during the summer following the workshop (Table 1). We solicited volunteers to conduct studies and assisted them by designing experiments and sampling protocols, and purchasing supplies as needed. During the research season these volunteers were supported using contacts via telephone, the Internet and U.S. mail. In each year except 2002, every garden researcher was visited to assist them with technical information and evaluate progress.

GARDENER SURVEY. We adapted a 1992 survey instrument (M. Dana, un-

published) to evaluate gardener use of various pest management practices because it enabled comparisons against a baseline estimate of practices that could be used to make inferences about the larger Master Gardener community. Response options included both tactics used and their frequency of use (Table 2). We asked gardeners to distinguish between alternative insecticides such as neem, that have relatively few adverse effects on beneficial organisms, and conventional insecticides such as carbaryl, that tend to have greater adverse effects the beneficial organisms that contribute to biological control of pests. Participants were surveyed at the beginning of each workshop to collect demographic information (gender, age, education, occupation, years as a Master Gardener, location of their garden) and to determine their use of pest management tactics in the season before the workshop. These individuals were surveyed again after the growing season following the workshop to determine changes in their pest management practices. In 1999 and 2001, participants who responded to the second survey were surveyed a third time to examine pest management practices two growing seasons after training. Demographic information was collected only in 1998–99. In 2001 and 2002 we focused the survey questions on the use of pesticides and biological control and dropped questions pertaining to other pest management practices. All responses were kept confidential and are reported here as summaries.

Table 2. Survey questions presented to all participants before and after attending day-long workshops on the principles and practices of biological control in home gardens between 1998 and 2002 in Indiana and Illinois.

Question I

How often did you use each of the following items or procedures against pests in your vegetable garden pest control program during the previous growing season? (Circle one code number for each item/procedure)

Items and procedures	1. Always	2. Usually (51% to 99% of instances)	3. Sometimes (1% to 50% of instances)	4. Never
Biological control	1	2	3	4
Use alternative insecticides [oils, soaps, neem, <i>Bacillus thuringiensis</i> (Bt), etc.] ^z	1	2	3	4
Use alternative herbicides (salts of fatty acid, corn gluten meal, etc.)	1	2	3	4
Mulching	1	2	3	4
Companion planting	1	2	3	4
Sanitation	1	2	3	4
Pest biology	1	2	3	4
Scouting	1	2	3	4
Record keeping	1	2	3	4
Removal of pests	1	2	3	4
Barriers	1	2	3	4
Traps	1	2	3	4
Conventional pesticides	1	2	3	4
Use pest-resistant varieties	1	2	3	4

Question II

Indicate your frequency of use for each type of pest control method during the previous growing season. (Circle one code number for each pesticide type.)

Pesticide type	1. Never used	2. Used once	3. Used 2–5 times	4. Used ≥6 times
Herbicide (weeds)	1	2	3	4
Insecticide (insects)	1	2	3	4
Fungicide (fungal diseases)	1	2	3	4

^zIn 1992, 1998, and 1999, alternative insecticides and herbicides were called alternative pesticides.

DATA ANALYSES. We compared participant use of pesticides and biological control to data from the 1992 survey to determine if we could combine data sets for analyses. Survey responses were analyzed using McNemar's test (Proc Freq Data McNemar; SAS Institute, Cary, N.C.), which assesses the directionality of a response variable; in our case the adoption of a pest management practice following a workshop (Sokal and Rohlf 1995). We used McNemar and chi-squared tests to examine adoption of biological control by researchers and nonresearchers based on their use of insecticides before and after workshops. All comparisons were made at $\alpha = 0.05$.

Results

Overall 42.5% (227) the 534 participants returned surveys in the season following training. Of these 227 respondents, 62 (27.3%) returned surveys two seasons following the workshop they attended. Workshop participants were predominantly female (78%) with an average age of 54 years (35 to 77 years). Most participants were college educated (76%), and were not involved in commercial agriculture or

horticulture (80%); 63% were Master Gardeners for >1 year and 65% lived in urban areas.

Before attending workshops, participants showed no consistent differences in their use of conventional pesticides and biological control compared to the 1992 survey of Indiana Master Gardeners (M. Dana unpublished data) (Table 3). For this reason we pooled data for further statistical analysis. Overall, the percentages of participants using cultural, mechanical and chemical control methods were similar to the 1992 Indiana Master Gardener population (Fig. 1). Before the workshop, most participants used

a variety of nonchemical and chemical garden practices to manage pests. Among practices, biological control was used by <50% of Master Gardeners. Overall 80% of participants used conventional insecticides at least one time during the growing season.

There was a significant reduction in the number of participants using conventional and alternative pesticides up to 2 years after training (Table 4). Although there was a 21% increase in participants using biological control in the season following the workshop, this was offset by 16% of participants who stopped using biological control (Table 4). Similar patterns in the use

Table 3. Use of biological control and conventional pesticides by Indiana Master Gardeners in 1992 and workshop participants before 1-d-long training session on the principles and practice of biological control in home gardens between 1998 to 2002 in Indiana and Illinois.

Year	Proportion using biological control (%)	Proportion using conventional pesticides (%)	N
1992	46.9	81.3	567
1998	39.3	76.6	163
1999	48.8	65.9	100
2001	37.0	80.0	128
2002	49.3	76.3	143

Fig. 1. Pest management practices of Master Gardeners (MGs) surveyed in 1992 compared with similar practices by MGs before and following workshops on the principles and practices of biological control held between 1998 and 2002 in Indiana and Illinois. Data on participant garden practices followed by the number 1 were collected in 1998 and 1999; Data on practices followed by the number 2 were collected in all years but 2002.

of biological control were seen in the second season after the workshop. As a result the McNemar's test showed no significant directionality in rates of biological control adoption among workshop participants.

Of the 534 participants, 161 (30%) conducted one or more research projects. Overall, after the workshop a significant percentage of workshop participants (at least 20%) stopped using conventional pesticides regardless of whether or not they conducted research (Table 5). This trend differed for alternative pesticides,

where significant numbers no longer using these materials was only noted among researchers. Interestingly, there was no increase in either the numbers of researchers or nonresearchers who adopted biological control in the season after the workshops. However, gardeners who reduced the number of insecticide applications and participated in research were more likely to adopt biological control than those gardeners who either did not participate in research or did not reduce their use of insecticides (Table 6).

Discussion

Similarities of survey responses of Master Gardeners entering our workshops with those surveyed in 1992 suggests that without additional training Master Gardeners are not likely to change their pest management practices over time. In some instances (e.g., mulching to control weeds) these practices are widely adopted and generally considered to be practical and environmentally sound. With >90% of Master Gardeners mulching, scouting, removing pests, and practicing sanitation (Fig. 1), it is doubtful that further training in these areas would significantly increase adoption rates. With other pest management technologies, such as the use of biological control or conventional pesticides there appears to be room for improvement. In the intervening 6 to 8 years since the 1992 survey, the use of biological control remained <50% while the use of conventional pesticides remained >75% (Fig. 1, Table 3). By concentrating on these two areas, our workshops and research program appeared to stimulate significant improvements, particularly in reducing pesticide use (Fig. 1, Tables 4 and 6). This emphasis on pesticide reduction appeared to have a sustained effect as over 20% of gardeners ceased their use of pesticides for up to 2 years following workshops (Table 4). Interestingly, we see declines in all classes of pesticides among researchers and nonresearchers (insecticides, herbicides and fungicides), perhaps related to our focus on the relationships among natural enemies and their alternative host plants (e.g., weeds), and nontarget effects of pesticides in general (Tables 4 and 5).

Table 4. Changes in pesticide and biological control use by workshop participants one and two growing seasons after attending 1-d-long workshops on the principles and practice of biological control in home gardens between 1998 to 2002 in Indiana and Illinois.

Type of pesticide	N	Seasons after training (no.)	Type of respondent change (% N)				McNemar's statistic ^z	P
			Begin to use	No longer use	Still do not use	Still use		
Herbicide	213	1	5.6	20.7	14.6	59.2	18.29	<0.01*
	55	2	5.45	20.0	10.9	63.6	4.57	0.03*
Insecticide	214	1	4.7	24.3	15.0	56.1	28.5	<0.01*
	55	2	3.6	27.3	20	49.1	9.9	<0.01*
Fungicide	208	1	6.7	27.4	33.7	32.2	26.04	<0.01*
	53	2	3.8	34.0	43.4	18.9	12.8	<0.01*
Alternative pesticide	135	1	5.2	17.8	6.7	70.4	9.32	<0.01*
	54	2	5.6	24.1	3.7	66.7	6.25	0.01
Biological control	209	1	21.5	16.3	29.2	33.0	1.53	0.22
	51	2	15.7	27.5	37.3	19.6	1.64	0.20

^zSokal and Rohlf, 1995.

Table 5. Use of pest management practices in the growing season after attending a 1-d-long workshop on the principles and practice of biological control in home gardens between 1998 and 2002 in Indiana and Illinois. Survey respondents are separated by their level of participation in research.

Pest management practices	Participation in research	N	Use of pest management practice (% N)				Significance	
			Begin to use	No longer use	Still do not use	Still use	McNemar's statistic ^z	P
Herbicide	Yes	86	9.3	22.1	14.0	54.7	4.48	0.03*
	No	127	3.2	19.7	15.0	62.2	15.20	<0.01*
Insecticide	Yes	85	3.5	29.4	14.1	52.9	17.29	<0.01*
	No	129	5.4	20.9	15.5	58.1	11.76	<0.01*
Fungicide	Yes	83	4.8	32.5	37.4	25.3	17.06	<0.01*
	No	125	8.0	24.0	31.2	36.8	10.0	<0.01*
Alternative pesticide	Yes	51	3.9	25.5	3.9	66.7	8.06	<0.01*
	No	84	6.0	13.1	8.3	72.6	2.25	0.13
Biological control	Yes	85	25.9	15.3	24.7	34.1	2.31	0.13
	No	124	18.6	16.9	32.3	32.3	0.09	0.76

^zSokal and Rohlf, 1995.

Table 6. Adoption of biological control (BC) by participants attending a 1-d-long workshop on the principles and practices of BC in Indiana and Illinois between 1998 and 2002. Survey respondents are separated by both their insecticide use practices in the season before and after attending the workshop and their level of participation in research.

Category of gardener by insecticide use	Participation in research	N	Use of pest management practice (% N)				Significance	
			Begin to use	No longer use	Still do not use	Still use	McNemar's statistic ^z	P
Never Used	Yes	13	30.8	7.7	15.4	46.2	1.8	0.18
	No	24	4.2	16.7	37.5	41.7	1.8	0.18
Use Less	Yes	40	35	10	30.0	25.0	5.56	0.02*
	No	56	17.9	17.9	33.9	30.4	0.0	1.0
Use More	Yes	30	16.7	23.3	23.3	36.7	0.33	0.56
	No	45	22.2	20	31.1	26.7	0.05	0.82
Use the Same	Yes	32	25.0	15.6	18.8	40.6	0.69	0.41
	No	41	14.6	17.1	34.2	34.2	0.08	0.78

^zSokal and Rohlf, 1995.

Adoption of biological control appears to hinge on two factors. The only group of gardeners who significantly increased their use of biological control included those who conducted research and also reduced their use of pesticides after workshops (Table 6). Both factors seem important because we note that researchers who did not decrease their pesticide use also did not increase their use of biological control, as did those who did not participate in research but did reduce their pesticide use (Table 6). Surprisingly, gardener-researchers who did not use pesticides before the workshop failed to show statistically significant increases in their use of biological control. Statistical comparisons may have been obscured by low numbers in this group. The 31% increase in biological control use by this group resulted in them having the highest percentage (77%) practicing biological control after the workshop (Table 6).

From an ecological standpoint, it is generally agreed that indiscriminant use of pesticides decreases the survival and effectiveness of natural enemies (Van Dreische and Bellows 1996). Thus in gardens where pesticides are the primary management tool, natural enemies have little chance to provide effective levels of control. The first step in increasing the use of biological control in the home garden is therefore to reduce pesticide use. In this way our workshop provided a chance for natural enemies to work as agents of pest control in the garden. However, our study also suggests that while a necessary condition, pesticide reduction in itself will be insufficient to increase rates of biological control adoption. The second step, participatory research, provides gardeners an opportunity to investigate biological control options that they may then tailor to their own garden needs. This two-step process provides extension specialists an op-

portunity to change gardener practices without requiring specific solutions to all possible combinations of crop-pest-natural enemy relationships. Enlisting gardeners in developing solutions to their pest problems has the potential to extend the impacts of Extension programs by increasing the number and diversity of pest management and other horticultural options available to gardeners.

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