Extension and Evaluation of a Simplified Monitoring Program in New York Apples

Arthur M. Agnello, Joseph Kovach, Jan P. Nyrop, W. Harvey Reissig, Deborah I. Breth, and Wayne F. Wilcox

ABSTRACT A 5-yr, simplified, pest-monitoring program was conducted in New York apple orchards, entailing individual instruction sessions with grower cooperators throughout the growing season. Program participants saved as many as 3.4 pesticide sprays in one year, for a savings of up to $77 per ha ($31 per acre). For the remainder of the time, pesticide applications and costs were comparable with those in conventionally managed blocks. Except for 1987, when an unrefined prediction model for one insect pest was responsible for unacceptable fruit damage at harvest, program blocks did not show significant differences in fruit quality from that obtained in conventionally managed blocks. Examination of participant compliance with recommended pest decisions indicated that growers were more risk-averse (in treating when not recommended) for direct fruit-feeding insects, but with successively greater reliance on scouting decisions for foliar pests, some tended to be slightly more lax than was recommended by program guidelines. A follow-up survey to evaluate participant attitudes and permanent changes in their practices found that many now rely on someone else to do their scouting for them. Those who scout their own orchards often use modified procedures or treatment thresholds, and most do not keep written pest-sampling records. A computer-based decision support system was developed to aid in the implementation of whole-farm pest management guidelines, but a lack of adequate support has curtailed efforts to maintain and upgrade its operating system and knowledge base. Therefore, this aspect of the program has been discontinued.

Much attention has been given to the difficulty of assessing grower implementation of integrated pest management (IPM) techniques and procedures. Program evaluation has always been one of the most problematic aspects of the extension process, and reports of statistics, such as attendance at training sessions and quantities of information resources distributed, are too frequently misrepresented as IPM successes, usually because genuine evaluative data are either too difficult to collect or too unfavorable to report. Reviews of IPM program implementation have addressed several types of problems encountered in presenting an objective measure of program success (Whalon & Croft 1984, Wearing 1988). One general characteristic of intensive IPM educational programs is that at a certain point, virtually all of the growers of a given commodity in a region become exposed to the principles and procedures being promoted, and their production practices are influenced to some degree that may not be quantifiable (Boutwell & Smith 1981). However, as pointed out by Douce et al. (1983), simply because producers have been exposed to IPM technology and even employ field scouts does not mean that the technology has been efficiently or properly incorporated into their crop production system. Another complication is that most attempts to estimate acreage under IPM practices tend to be conservative, necessarily focusing on the incorporation of multiple management tactics within the context of formal IPM programs, and disregarding the use of single tactics on nonmonitored acreage, an admittedly complicated undertaking. Whalon & Croft (1984) estimated less than 12% of North American apple acreage to be under direct IPM practices in 1982, but proposed that the actual acreage influenced indirectly by IPM likely exceeded 95%.

Economists and sociologists have acknowledged that the manner in which growers assimilate IPM recommendations into their farming operations may best be perceived from a point of view of risk management. Whereas the subsistence farmer traditionally sought to minimize risk in the long term, the modern commercial farmer's objectives are to maximize profit as well as to minimize risk in the short term (Corbet 1981). This may not always take the form of simply choosing a strategy expected to result in the highest net crop value, but, especially if the grower is averse to taking risks, preferring an approach that reduces the variability of the outcome (Mumford & Norton 1984). Uncertainty diminishes the desirability of an outcome, so information that reduces uncertainty should be of value to the grower. From a farm-scale perspective, IPM methods may be regarded essentially as tools for managing risk by substituting knowledge and information for uncertainty. Pesticides similarly reduce production risk, but differ in that they serve more as an insurance input when applied on a protective schedule (Hall 1977, Antle 1988). Wearing (1988) has summarized many of the competitive advantages of using routine chemical control over scouting-based treatment decisions, which range from the established infrastructure for pesticide supply, marketing, and use, to the chemicals' affordability, ease of use, and reputation of reliability derived from grower experience.

Some pest management considerations are defined primarily by historical patterns or established social and economic structures, such as grower reliance on chemical fieldmen, or the difficulty in justifying the labor required to monitor individual orchards in highly mechanized farming operations. Although such shaping forces are difficult to affect directly, it is nonetheless possible to address some of the educational factors influencing adoption and implementation of IPM techniques. The application of integrated pest control methodology is constrained by a basic lack of knowledge by farmers (and in many cases, advisors, policy makers, pesticide producers, and even research or extension faculty) of nonchemical means of pest control, and insufficient experience in making use of them, which contributes to a prevailing belief that such methods cannot possibly be as effective as chemical pesticides (Gruys 1982). Several authors have reported on the outcomes of farm-based IPM demonstrations, and many others have identified as key to the success of large-scale programs the need for monitoring and sampling procedures that are simple, realistic, and able to be learned and followed by growers or managers on their own farms (Glass 1975, Tette et al. 1979, Corbet 1981, Gruys 1982, Goodell 1984, Lambur et al. 1985, Wearing 1988, Nowak 1991). Such guidelines would ostensibly allow growers to omit unnecessary treatments without risking undue economic losses. By increasing the ability of a grower or consultant to survey and understand an orchard situation, simple monitoring procedures could reduce the complexity of an IPM approach and, conceivably, increase the amount of acreage a pest consultant could effectively survey.

Some form of IPM methodology has been promoted in New York apple orchards since 1972 (Glass 1975; Tette et al. 1979, 1987; Whalon & Croft 1984). The earliest efforts emphasized reduced pesticide programs and employed treatment recommendations based on weekly orchard inspections, insect trap catches, and weather conditions. Later, a farm adviser IPM program was started that assessed per-acre fees for regular scouting and management services and provided a training opportunity for individuals wishing to pursue a private career in this area. Acreage under this program increased, information on pest biology and management was incorporated into traditional avenues of the extension process, and a computer-based information system was instituted (Sarette et al. 1981) that made use of pest development models. Subscribership and fee structure developed to the point that a private IPM cooperative formed in 1982 and hired its own IPM adviser and scout. Eventually, however, personnel losses and diminished financial support caused many of the formal aspects of the state's apple IPM program to be abandoned or decline into relative inactivity (Tette et al. 1979, Whalon & Croft 1984). A telephone survey in 1985 determined that a complete IPM approach was being used on 8% of the apple acreage in New York, and portions of the IPM approach were being used on 73% of the remaining acreage (Tette et al. 1987).

Through conversations with growers, consultants, and extension agents, including responses to the 1985 telephone survey, several constraints were identified regarding the adoption of the proposed apple IPM technology in New York. First, the program being promoted was very labor intensive; it required that all orchards be scouted every week and a large number of pests (as many as 20–25 arthropods and diseases) monitored throughout the growing season. Second, there were decreasing numbers of private and chemical industry field consultants available for employment by growers to provide such monitoring services, and the growers lacked the knowledge or training to do the monitoring themselves. Also, those growers who were able to hire an orchard consultant found that the cost of such a service was comparable with their perceived savings in pesticide sprays. A particular need also was expressed for renewed attention to the growing problems in managing spider mite populations that was attributable to acaricide resistance (Welty et al. 1987, Dennehy et al. 1988) and the unavailability of some acaricides because of regulatory decisions. In 1987, in response to requests from several segments of the apple industry, the Cornell IPM Program, together with the Entomology Department and, later, the Plant Pathology Department of the New York State Agricultural Experiment Station at Geneva, initiated a Simplified Monitoring Program (SMP) to address the need for information that would enable growers to make their own scouting-based management decisions.

The four objectives of the SMP were to: (1) teach growers or private consultants how to use simplified, formalized, sampling procedures, based on specific action thresholds, to evaluate the need for treatment of a limited number of key arthropod pests; (2) control pests when necessary by selecting pesticides that are the least destructive to predatory mites; (3) minimize the amount of time spent monitoring in the orchard by careful timing of control decisions needed; and (4) test the ability of relatively untrained participants to learn formalized sampling techniques quickly and their willingness to adopt management practices slightly different from those commonly used. The pests addressed in the program were: rosy apple aphid, *Dysaphis plantaginea* (Passerini); spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabricius); obliquebanded leafroller, *Choristoneura rosaceana* (Harris); European red mite, *Panonychus ulmi* (Koch); apple maggot, *Rhagoletis pomonella* (Walsh); and apple scab, *Venturia inaequalis* (Cooke) Winter. Each of these pests is a serious problem in some blocks each year, but it is difficult to predict their severity in a given block from one year to the next, or even between generations in the same season; therefore, growers frequently opt for calendar-based preventive sprays in the absence of any documented need. More importantly, attention was given to these pests because recent research on each had provided good IPM alternatives to weekly orchard visits or prophylactic sprays. Reported here are the results of the 5 yr during which this program was in operation, a summary of the monitoring procedures used (Table 1), and results of a follow-up interview of all participants—conducted 1 yr after the end of formal demonstrations, to assess the extent to which growers still used the techniques taught.

Materials and Methods

1987. Cooperators were solicited from among the growers and private consultants in the state's western fruit region, mostly in the counties along the southern shore of Lake Ontario. Each cooperator was asked to contribute one block ≈2–4 ha in size, preferably of a variety relatively tolerant to rosy apple aphid, such as 'McIntosh', because at the time there were no reliable sampling guidelines developed for this pest. Growers were asked to avoid using materials shown to be detrimental to predatory mites, such as pyrethroids, dimethoate, formetanate hydrochloride, and glyodin. Similarly, because the only effective way to reduce fruit damage from tarnished plant bug, *Lygus lineolaris* (Palisot de Beauvois), is through the use of materials destructive to predatory mites (Weires et al. 1985), it was specified that the candidate orchard not have a history of problems from this insect. A prebloom application of petroleum oil was recommended between the half-inch green and tight-cluster bud development stages for early-season control of European red mite (Wilcox et al. 1987). Growers were asked to follow their normal management practices for fungicide applica tions, minor insect pest decisions, and thinning and foliar nutrients.

Each time a management decision was required based on sample counts of arthropods, one or two university or local extension

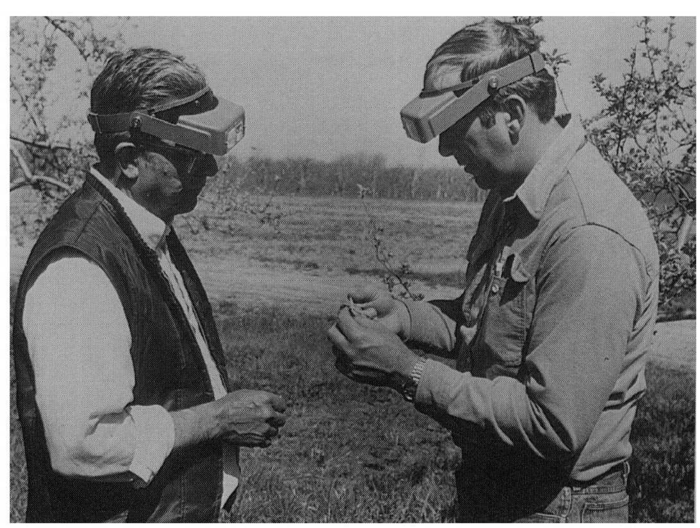

Fig. 1. Harvey Reissig (r.) instructs a grower, Ralph Brown of Waterport, NY, how to sample first generation spotted tentiform leafminer eggs.

Table 1. Summary of management decision guidelines for key apple pests before, during, and after SMP, New York

Pest Decision[a]	1986	SMP 1987	SMP 1988	SMP 1989	SMP 1990	SMP 1991 and afterwards
Apple Scab	6–7 protective sprays from silver tip through June, according to weather-based infection periods.	NC	Application of a sterol DMI fungicide at tight cluster, pink bud, petal fall, and 10 d after petal fall.	NC	NC	NC
RAA	No sampling guidelines. Thrsh: 1 colony/10 term, from 1/2-inch green to pink bud.	NC	Fixed-count sample at pink bud: 10 fruit clus from each of 10 trees. Thrsh: 5 infested clus.	Same sampling guidelines. Thrsh: 1 infested clus.	NC	NC
STLM1	No sampling guidelines. Thrsh: 1 mine/leaf from pink bud to petal fall.	Fixed-count sample at pink bud: 3 lvs per fruit clus, 4 clus from each of 5 trees. Thrsh: 1 egg/leaf.	NC	NC	Sequential sample at pink bud (thrsh: 2 eggs/leaf) or petal fall (thrsh: 1 sap-feeding mine/leaf). Max, 7 trees.	NC
OBLR1	No sampling guidelines. Thrsh: 3% infested clus and terms at petal fall.	Sequential sample at late pink bud: 10 clus/tree (max, 250 clus). Thrsh: 3% infested clus.	Same sampling method, but during bloom (max, 100 clus); same thrsh.	NC	NC	NC
ERM	No sampling guidelines. Thrsh: 5 nymphs/leaf at pink bud to petal fall, 6 motiles/leaf thereafter.	Binomial sequential samples through summer: 4–5 lvs/tree (max, 100 lvs). Date-dependent thrsh: 3, 5, or 7.5 motiles/leaf.	Same sampling method; date-dependent thrsh: 3, 5, 7.5, or 10 motiles/ leaf.	Same sampling method and thrsh, but thrsh dates modified	Same sampling method; cascaded tripartite decision points. Thrsh dates rearranged using 2.5, 5, or 7.5 motiles/leaf.	NC
OBLR2	No sampling guidelines. Thrsh: 5–10% infested terms from late June to early July.	Sequential sample 400 DD (base 6°C) after 1st moth catch: 10 terms/tree (max, 196 terms); thrsh: 12% infested terms.	Same sampling method (max, 100 terms); thrsh: 10% infested terms.	Same sampling method, 333 DD after 1st moth catch. Thrsh: 3% (fresh) or 10% (processing) infested terms.	NC	NC
STLM2	No sampling guidelines. Thrsh: 2 second brood mines/ leaf.	Fixed-count sample after peak adult flight: 10 term lvs from each of 5 trees; thrsh: 2 sap-feeding mines/leaf.	NC	NC	Sequential sample 10 d after peak adult flight (max, 50 lvs). Same thrsh.	Cascaded tripartite sequential sample 350–390 DD (base 6°C) after 1st moth catch of 2nd brood. Same thrsh.
AM	Calendar-based sprays after catch of 1st fly on yellow board trap.	Unbaited red sphere traps, checked 1–2 times/week; thrsh: 1 fly caught.	Volatile-baited sphere traps, same monitoring method; thrsh: 5 flies/trap.	NC	NC	NC

SMP, Simplified Monitoring Program. DMI, demethylation inhibitor. NC, no change from previous year's management recommendations. Thrsh, threshold. Term, terminal. Clus, cluster(s). Lvs, leaves. Max, maximum sample number possible. DD, degree-days.

[a]RAA, rosy apple aphid. STLM1, first generation spotted tentiform leafminer. OBLR1, overwintered generation obliquebanded leafroller. ERM, European red mite. OBLR2, first summer generation obliquebanded leafroller. STLM2, second generation spotted tentiform leafminer. AM, apple maggot.

representatives visited each farm at the appropriate time and taught the specific sampling procedure to the cooperator and any farm employees who wished to participate (Fig. 1). Then the cooperators and program representatives conducted independent samples in the block. Times required for the instruction and sampling were recorded, and sample results were compared to determine whether the same decision was reached in all cases. Although the sampling procedures resulted in definite spray recommendations, some thresholds were considered experimental and so growers were encouraged but not obliged to follow the recommended management decision. Following is a summary of the pest management decision sequence used in the program during 1987:

Diseases. A preventive fungicide schedule was maintained throughout the season for the control of apple scab and other diseases such as powdery mildew, *Podosphaera leucotricha* (Ellis & Everhart) Salmon; sooty blotch, *Gloeodes pomigena* (Schweinitz) Colby; and flyspeck, *Schizothyrium pomi* (Montagne & Fries) Arx. Captan was avoided during the period when oil was applied because of potential phytotoxicity problems.

European Red Mite, Early Season. A 2% petroleum oil application was recommended at the half-inch green bud stage, or 1% at tight-cluster, to control overwintered eggs (Chapman & Pearce 1949). Alternatively, an application of oxythioquinox, cyhexatin, or dicofol at the pink bud stage could be elected.

Spotted Tentiform Leafminer, First Generation. At the early pink bud stage, after egg-laying activity had peaked, eggs were counted on the undersides of fruit cluster leaves. A headband-mounted binocular magnifier (Optivisor; Donegan Optical, Lenexa, KS) was used to facilitate the counting, and an average of one egg per leaf was the treatment threshold. If treatment was elected, oxamyl or the insect growth regulator diflubenzuron was recommended before bloom or, alternatively, methomyl against the early-instar larvae at petal fall.

Obliquebanded Leafroller, Overwintered Generation. Fruit clusters were sampled for live larvae at the late pink or early bloom stage. A sequential sampling procedure was followed that required examining a maximum of 250 total clusters, with a treatment threshold of 3% infested clusters. If treatment was elected, a recommendation was made to include microencapsulated methyl parathion in the petal fall spray.

Plum Curculio, Conotrachelus nenuphar *(Herbst).* Because of the widespread occurrence of this pest and lack of an appropriate scouting procedure or economic threshold, no sampling was conducted and a preventive spray of an organophosphate insecticide was recommended at petal fall.

European Red Mite, Summer Generations. Beginning in mid-June, a binomial sequential sampling procedure was used to classify density according to action thresholds, which varied with the date (Nyrop et al. 1989). Intermediate-aged leaves were examined for motile mites, and populations in the block were classified according to treatment thresholds of 3.0 (5–25 June), 5.0 (26 June–5 August), and 7.5 (5–31 August) mites per leaf. Sampling sessions were conducted twice during the 5.0-per-leaf period, and once during each of the other periods. An above-threshold sample prompted a recommendation to apply dicofol or propargite.

Obliquebanded Leafroller, First Summer Generation. Expanding leaf terminals were sampled for second through fourth instar larvae, timed at ≈400 degree-days (DD) (base 6°C) after the first regional pheromone trap catch of male moths (Onstad et al. 1985). A sequential sample was conducted similar to that of the overwintered generation, but the treatment threshold was 12% infested terminals and the potential maximum number of sampled terminals was 196. Micro-encapsulated methyl parathion was recommended in the case of an above-threshold decision.

Spotted Tentiform Leafminer, Second Generation. After the second adult flight peak, in mid-July, mature terminal leaves were randomly selected and the undersides were examined for early (sap-feeding stage) mines of the second generation. An application of oxamyl was recommended if an average of more than two mines per leaf were found.

Apple Maggot. In late June, three unbaited red sphere traps (Prokopy & Hauschild 1979) were placed in each orchard to monitor immigrating apple maggot adults. Traps were located along the orchard edge closest to the most likely source of incoming flies—stands of woods or shrubs, or else the southern edge of the planting—in trees ≈10 m apart. At the field session, program participants were taught proper trap placement and how to identify apple maggots; a picture identification sheet was provided as a field aid. Participants were instructed on how to check the traps one or two times per week and to clean and resurface them as needed. An application of azinphosmethyl or phosmet was recommended with the capture of one apple maggot fly after which the traps could be ignored for the period of the pesticide's residual effectiveness (10–12 d). Trap checking was to resume after this time and to continue until the middle of August. Because of the low industry threshold for apple maggot damage, Cooperative Extension personnel also independently checked all the traps each week to ensure that no catches went undetected.

A total of 18 cooperators participated, 1 was a farm manager, 4 were private pest consultants, and the rest were commercial growers. The farms involved were located in Monroe, Niagara, Onondaga, Ontario, Orleans, and Wayne counties. The total area of the 19 orchard blocks enrolled was ≈56 ha, with an average block size of 3.0 ha (range, 1.1–6.1 ha), and was composed of the following apple varieties: 'Baldwin', 'Cortland', 'Ida Red', 'Jonamac', 'Jonathan', 'McIntosh', 'Monroe', 'Paula Red', 'Red Delicious', 'Rhode Island Greening', 'Rome', and 'Twenty Ounce'. Approximately 80% of the fruit produced was destined for the fresh market. Sampling sessions for two pests were sometimes combined during a single visit and so all sessions were conducted in the course of six total visits to each block, excluding the apple maggot trap readings. Evaluations of fruit quality were conducted at harvest in each block and in a comparable block at each farm that was managed using the grower's conventional practices. Random samples of 100 fruits from each of 10 trees per orchard were picked and inspected for direct insect or disease injury. All sampling results, treatment decisions, and pesticide sprays were recorded for both SMP and comparison blocks. At the end of the year, an evaluation meeting was held to enable participants to offer their impressions and criticisms of the program with university and extension personnel; a total of 21 cooperators and farm employees attended. A questionnaire was distributed that tested participants' comprehension and retention of sampling techniques, rationale, and underlying biological principles, and also asked for assessments of how well the program's objectives were met.

1988. A group of 23 cooperators participated in the program, which consisted of 13 growers, 1 farm manager, and 3 private consultants who were experienced with the program in 1987, plus 1 farm manager and 5 growers who were new to the program. There were 23 separate orchard blocks involved, with an average size of 2.8 ha (range, 1.0–6.1 ha), for a total area of 63.7 ha; all blocks were located in the same counties as those represented in the previous year's program and the same blocks were used by repeat participants. Some of the arthropod and disease control guidelines used in 1987 were modified as follows to incorporate newer research findings and to correct some shortcomings of the existing procedures:

Diseases. Instead of using the conventional approach of applying 6 or 7 protectant fungicide sprays from budbreak until 1–3 wk after petal fall, a reduced-spray program was implemented for control of primary apple scab infections. Growers were advised to make four applications of a sterol demethylation inhibitor (DMI) fungicide (fen-arimol, flusilazol, or myclobutanil), whose timings were to be independent of the occurrence of apple scab infection periods but were to coincide with applications of insecticides or acaricides at or near the following four tree phenological stages: tight-cluster, pink bud, petal fall, and ≈10 d after petal fall (first cover spray) (Wilcox et al. 1992).

Rosy Apple Aphid. Data collected the previous spring on the within- and between-tree variability of rosy apple aphid abundance provided information suggesting acceptable numbers at pink bud (J.P.N., unpublished data). A sampling procedure was incorporated at the pink bud stage, wherein fruit clusters from the interior tree canopy region were evaluated for the presence of wingless adults or nymphs. An application of a material such as phosphamidon was recommended if five infested clusters were found. This procedure was conducted during the same field session as that for first generation spotted tentiform leafminer; if an above-threshold decision was reached for both insects, a pesticide such as oxamyl was recommended at pink bud.

Obliquebanded Leafroller, Overwintered Generation. Fruit clusters were sequentially sampled in the same way as in 1987, but the stop-sampling limits were altered to reduce field sampling time so that a decision could be made after examining a maximum of 100 total clusters, based on an infestation threshold of 3%.

European Red Mite, Summer Generations. Binomial sequential sampling of intermediate-aged leaves was conducted once again, but the threshold mite densities at different times of the summer were modified, based upon field observations and predictive modeling of mite population dynamics during the previous year: petal fall–15 June, 3.0; 16–30 June, 5.0; 1–15 July, 7.5; and 16 July–1 August, 10.0 mites per leaf. Mite populations remaining below these thresholds until 1 August were considered not to need additional sampling or acaricide treatments.

Obliquebanded Leafroller, First Summer Generation. The same sampling procedure and timing schedule was used as in 1987, but with modifications in the procedure to allow a decision after a maximum of 100 clusters using a 10% infestation threshold.

Apple Maggot. Red sphere traps were hung in the participating orchards as before; however, because of research on the effectiveness of using these traps in combination with apple volatile lures, each trap was provided with a commercially produced lure (Biolure; Consep Membranes, Bend, OR) baited with butyl hexanoate and the treatment threshold was raised to an average of five apple maggot flies per trap (Agnello et al. 1990a).

Expert System. In addition to the on-farm instruction component of this program, six of this season's participants—four growers and two farm managers—volunteered to receive their directions for the pest sampling procedures and management decisions within the context of a field validation of a computer-based decision support system being developed concurrently to coach the implementation of IPM techniques in apples. The Expert Advisory System for Managing Pests in Apple Cropping Systems (EASY-MACS) (Huber et al. 1990) is a set of computer programs and data files designed to help apple growers make informed pest management decisions when considering multiple pest control goals. The system was initially made available for use with Apple Macintosh computers (Apple Computer, Cuptertino, CA) and was created with commercially available development tools. It consists of data entry and review screens with an expert system knowledge base incorporating facts, generalities, opinions, and heuristic knowledge pertaining to current apple IPM strategies.

All participants were provided with a manual that detailed each of the sampling procedures including sampling charts and data sheets, the rationale behind recommended management decisions, pest identification sheets, and other pertinent information for reference and background. Harvest evaluations of fruit damage were conducted similarly to 1987 except that 200 randomly chosen fruits were inspected from each of five trees per orchard.

1989. A group of 53 cooperators participated in the program and consisted of 14 growers, 2 farm managers, 3 private consultants (of whom 16 had participated the previous 2 yr and 3 the previous season only), and 34 new growers. There were 53 separate orchard blocks involved with an average size of 2.7 ha (range, 1.0–8.1 ha), for a total area of 130 ha. In addition to the blocks located in the same sites as in the previous 2 yr, four of the new growers were farther east along Lake Ontario in Oswego and Onondaga counties and 10 were located in Dutchess and Ulster counties, in the Hudson River Valley. To evaluate another method of extending these management techniques to potential users, the SMP sampling procedures were taught to four private pest consultants in Wayne County who each agreed to teach these methods to five of their grower clients and evaluate the success of their pest management efforts. Some of the arthropod control guidelines used in 1988 were again modified as follows to incorporate newer research findings and to correct some shortcomings of the existing procedures:

Rosy Apple Aphid. The sampling session proceeded as in the previous year, but because some participants had difficulty detecting small numbers of aphids in a fruit bud, the threshold was dropped to 1% infested clusters and this required a treatment decision as soon as an aphid colony was found.

European Red Mite, Summer Generations. Binomial sequential sampling of intermediate-aged leaves was conducted as before, but additional modifications were made to the threshold mite densities: petal fall–25 June, 3.0; 26–15 July, 5.0; 16–5 August, 7.5; and 5–15 August, 10.0 mites per leaf. Mite populations remaining below these thresholds until 15 August were considered not to need additional sampling or acaricide treatments.

Obliquebanded Leafroller, First Summer Generation. By the end of the 1988 season, it was evident that this insect had begun to exhibit tolerance to many of the pesticides used in the different orchards (Reissig & Agnello 1992), resulting in unacceptable fruit damage in some blocks. Therefore, to ensure that larvae were not too large to control effectively at the time the treatment decision was made, the timing of the sampling session was advanced to correspond to ≈333 DD (base 6°C) after the first regional pheromone trap catch of male moths with any needed pesticide treatments to be applied no later than the 400 DD timing. If a timely sample resulted in a below-threshold decision, a second sample was recommended in 3–5 d. Because of the mostly cosmetic nature of damage resulting from incomplete control of this leafroller, the sampling chart based on a 3% terminal infestation threshold was recommended for fresh fruit and the procedure using a 10% threshold was reserved for fruit intended for the processing market.

Once again, all participants in the program were provided a scouting manual, which was also made available through conventional university extension channels (Agnello et al. 1989). In addition, a video tape was produced to demonstrate the sampling procedures for all the arthropod pests at different times of the season (Agnello & Kovach 1989). Because of personnel changes and modifications being made to the EASY-MACS operating system, no expert system field demonstrations were conducted this year.

1990. The SMP procedures were taught to a private consultant in the Hudson Valley region at the appropriate times of the season; he then conducted them on designated blocks belonging to six of his regular clients located in Ulster County, constituting a total of 13.2 ha of 'Jonamac', 'Empire', 'Spartan', 'McIntosh', and 'Red Delicious' apples marketed as fresh fruit. The following modifications were made to the previous year's SMP procedures:

Spotted Tentiform Leafminer, First Generation. The fixed-count egg sample was replaced with a sequential sampling procedure for eggs at the pink bud stage or, alternatively, for sap-feeding mines at the petal fall stage (Nyrop et al. 1990). The procedure employed a treatment threshold of two eggs or one mine per leaf, respectively.

European Red Mite, Summer Generations. To minimize concerns over the potential effect of high mite populations on fruit

Table 2. Pesticide treatment recommendations resulting from sampling sessions in SMP blocks, 1987–1990

Sampling session	Avg sampling time (min)	1987		1988		1989		1990		Total	
		n[a]	%[b]	n	%	n	%	n	%	n	Avg %
Rosy apple aphid	13.5	—	—	17	47.1	49	55.1	6	0.0	72	48.6
Spotted tentiform leafminer 1[c]	7.6	19	21.1	17	17.6	50	16.0	6	0.0	92	16.3
Obliquebanded leafroller 1[d]	14.7	19	10.5	17	47.1	40	27.5	—	—	76	27.6
European red mite 1[e]	8.3	19	5.3	17	0.0	32	3.1	4	0.0	72	2.8
European red mite 2[e]	11.4	19	26.3	17	11.8	22	9.1	4	50.0	62	17.7
European red mite 3[e]	16.5	19	31.6	17	29.4	22	45.5	4	25.0	62	35.5
European red mite 4[e]	15.2	19	5.3	17	23.5	22	36.4	—	—	58	22.4
Obliquebanded leafroller 2[c]	13.2	19	5.3	17	41.2	40	42.5	4	0.0	80	31.3
Spotted tentiform leafminer 2[c]	12.6	19	5.3	17	11.8	47	4.3	4	25.0	87	8.0
Apple maggot[f]	94.7	19	100.0	17	94.1	24	18.6	4	100.0	64	73.4
	Total time 3.46 h		(2.3, 1–4)		(1.7, 0–3)		(0.2, 0–1)		(2.8, 2–4)		(1.1, 0–4)

[a]Number of blocks sampled.

[b]Percentage of blocks for which a "treat" recommendation was made; for apple maggot, mean number and range of "treat" recommendations per orchard also given, in parentheses, based on trap catches between 1 July and 15 August.

[c]Spotted tentiform leafminer 1, first generation. Spotted tentiform leafminer 2, second generation.

[d]Obliquebanded leafroller 1, overwintered generation. Obliquebanded leafroller 2, first summer generation. Threshold levels and timing of sample session varied among seasons.

[e]Dates of sample sessions: 1987, 1: 15–26 June; 2: 29 June–2 July; 3: 14–16 July; 4: 5–7 August. 1988, 1: 7–8 June; 2: 16–21 June; 3: 13–15 July; 4: 25 July–9 August. 1989, 1: 12–13 June; 2: 26–27 June; 3: 24–25 July; 4: 14–15 August. 1990, 1: 3–28 June; 2: 2–31 July; 3: 5–19 August.

[f]Sampling time reflects reading and servicing of traps twice per week.

color in certain 'Red Delicious' strains, the 10.0 mites-per-leaf threshold period was eliminated and the other three threshold levels were rearranged to compensate as follows: petal fall–30 June, 2.5; 1–31 July, 5.0; and after 31 July, 7.5 mites per leaf. Mite populations remaining below these thresholds until 15 August were considered not to need additional sampling or acaricide treatments.

Spotted Tentiform Leafminer, Second Generation. The fixed-count sample was replaced with a sequential sampling procedure that was timed to occur ≈10 d after the peak pheromone trap catch of male moths (Schmaedick 1993). The treatment threshold remained at two mines per leaf.

Additional efforts were made this year to promote the use of the EASY-MACS expert system primarily through distribution and demonstration to Cooperative Extension personnel. Procedures for using the system were taught to three regional extension fruit specialists and eight Lake Ontario region growers to evaluate its implementation at the commercial farm level and to validate its user protocols. In the fall, a brief survey was sent to EASY-MACS purchasers (in New York and elsewhere) to determine the extent of actual system usage, to identify trouble spots, and to evaluate interest in using EASY-MACS the next year. All participants in this year's program were again provided with an updated scouting manual that was also made available through conventional university extension channels (Agnello et al. 1990b).

1991. The sampling procedure for second generation spotted tentiform leafminer was modified as follows and all the SMP sampling guidelines were incorporated into both a revised scouting manual (Agnello et al. 1991) and the commercial tree fruit pest management recommendations (Stiles et al. 1991):

The sequential sampling procedure was altered to employ a tripartite decision scheme with the following possible outcomes: "Over threshold, treat"; "Under threshold, resample in 3 days"; or "Under threshold, don't treat" (Schmaedick 1993). To compensate for variability in local moth flight peaks, the timing of the sample was changed to correspond to 350–390 DD (base 6°C) after the first regional pheromone trap catch of male moths.

Expert System. A regional extension specialist entered sampling results and leaf wetness data into the EASY-MACS expert system to obtain management recommendations for mites, leafrollers, apple maggot, and apple scab in 10 orchards across the Lake Ontario region on a total of 21.9 ha. A technician was trained to scout orchards to monitor the key pests, and growers cooperating in the field validation were included in the training sessions as their schedules allowed. The system was employed as it would be by a private consultant working in numerous blocks on many farms. Data on pest infestations were collected throughout the season, spray records were maintained, and harvest evaluations of fruit quality were conducted on 100 apples from each of 5 trees within each block.

Survey. From July–September, a follow-up interview was conducted with all previous program participants who were still managing apple orchards to evaluate their retention of the methods they were taught and their residual compliance with the recommended pest control decision practices. A total of 35 cooperators in 10 counties were interviewed, mostly in person at their farm (5 by telephone), of these 28 were growers, 4 were consultants, and 3 fell into both categories. They were responsible for pest management decisions on a total of 3,254 ha of apples (13% of the state's total acreage) of which 61.7% was intended for the fresh fruit market. The survey, which required an average of between 30 and 45 min to administer, addressed the following three aspects of their pest control practices:

(1) The person with responsibility for sampling and making final pest control decisions on the farm; frequency or extent of referral to recommended guidelines; adherence to selected traditionally recommended pest control practices.

(2) Use of the recommended SMP scouting technique for a given pest; modifications to the recommended technique; reasons for not sampling; other criteria used to determine the need for treatment; compliance with sample decision recommendations; reasons for noncompliance.

(3) Use of more progressive IPM practices such as pheromone trapping; maintenance of DD records; use of specific selective insecticides such as insect growth regulators (when available) or *Bacillus thuringiensis* materials; use of a magnifier or hand lens while scouting; maintenance of written records of pest sampling sessions; use of a personal computer in farm operations.

Results

1987–1989. The outcome of the pest sampling sessions conducted in the SMP cooperators' orchards are summarized in Table 2 for the 4 yr during which samples were directly administered by college or extension personnel. The number of blocks sampled for the different pests in 1989 varied according to the data available from blocks being administered by the private pest consultants. The amount of time required to teach participants the different sampling protocols averaged between 2.7 and 4.3 min for spotted tentiform leafminer, between 3.9 and 7.8 min for obliquebanded leafroller, between 2.8 and 6.6 min for European red mite, and ≈5 min for apple maggot. The average time required for participants to complete the sampling procedures ranged from 7.6 to 16.5 min, with the spotted tentiform leafminer and initial European red mite sessions being the shortest. The later mite samples required the greatest amount of time because of the need to examine larger numbers of leaves as populations approached threshold infestations in mid-summer. Apple maggot traps were serviced an average of twice weekly for 6 wk, so the average time requirement for this insect was 7.9 min per visit. The average time required to conduct all of the sampling and monitoring procedures using the SMP protocols totaled ≈3.5 h per season for a representative orchard block an average of 2.7 ha in size.

The percentage of above-threshold or "treat" decisions reached among all orchards visited also is reported in Table 2 for each pest sampling session; for apple maggot, the mean number of "treat" recommendations per orchard is given and is based on trap catches between 1 July and 15 August. In a small number of cases (<5% overall), sampling procedures in a given orchard produced a split decision—a below-threshold result reached by one participant and an above-threshold by another. These situations were assumed to represent a pest density close to the action threshold and were, therefore, interpreted conservatively as a "treat" decision.

A number of trends were evident during this period. Rosy apple aphid was deemed to be above treatment threshold levels in approximately half of the orchard blocks for the 3 yr they were sampled. Averaged over the entire 4-yr period, above-threshold decisions were reached in only 16.3% of the blocks for first generation spotted tentiform leafminer and 8.0% for second generation populations. European red mite patterns were similar all 4 yr; they increased to their highest densities by the mid-July sampling sessions (i.e., session 3 in 1987–1989, session 2 in 1990) and then subsided somewhat during the next 2 wk. Results of the obliquebanded leafroller sessions were more variable, possibly because of the differences in sampling methods and thresholds used each season. Unacceptable fruit damage caused by the summer generation necessitated annual refinements to the sampling protocol for that brood, and so it is possible that the procedure used in 1987 was actually failing to identify above-threshold populations. An average of ≈42% of all blocks sampled required treatment for summer leafrollers if just the 1988–1989 numbers are considered (the 1990 data are from the Hudson Valley, where this species does not occur frequently). For apple maggot in the western part of the state, the mean number of trap-based "treat" recommendations per orchard decreased from 2.3 in 1987 to 0.2 in 1989. Although some of this variation may have resulted from the effects of different summer weather conditions on apple maggot populations, some may also be attributable to the fact that the trapping procedure was changed in 1988 by using a volatile-baited sphere and a higher treatment threshold. "Treat" decisions were more numerous during the only season (1990) these data were collected in the Hudson Valley. It is not possible to determine whether this

Table 3. Mean percent (SEM) fruit in nonexclusive pest damage categories at time of harvest in SMP and comparison blocks, 1987–1989

Year	Block	Clean	n[a]	Fruit scab	Early Lepidoptera[b]	Late Lepidoptera[c]	Tarnished plant bug	Plum curculio[d]	Rosy apple aphid	Apple maggot	San Jose scale	Sting[e]	White apple	Summer disease
							Western New York							
1987	SMP	90.0a (6.5)	19	0.4a (1.0)	0.1a (0.1)	7.3a (6.4)	1.1a (1.8)	0.3a (0.4)	—	0.0	0.3a (0.6)	0.2a (0.4)	—	—
	Comparison	93.8b (4.5)	18	0.6a (1.3)	0.1a (0.2)	3.7b (3.5)	0.6a (1.1)	0.3a (0.5)	—	0.0	0.2a (0.5)	0.2a (0.3)	—	—
1988	SMP	90.4a (6.1)	21	0.3a (0.7)	0.8a (1.1)	4.7a (4.2)	1.2a (1.1)	1.1a (1.4)	0.4a (1.0)	0.2a (0.6)	0.2a (0.5)	0.6a (0.8)	—	—
	Comparison	93.4a (5.1)	14	0.7a (1.0)	0.3a (0.5)	3.1a (3.0)	0.8a (1.2)	0.4a (0.5)	0.1a (0.5)	*tr* a (*tr*)	*tr* a (*tr*)	1.1a (1.9)	—	—
1989	SMP	89.4a (7.7)	39	2.8a (4.7)	0.3a (0.7)	3.9a (3.8)	0.7a (1.4)	0.8a (1.4)	0.1a (0.3)	0.1a (0.3)	0.2a (0.6)	0.6a (0.8)	—	—
	Comparison	88.8a (9.2)	30	2.3a (3.9)	0.4a (0.7)	3.3a (4.2)	0.6a (0.7)	1.3a (3.7)	0.6a (2.1)	*tr* a (0.1)	0.1a (0.2)	0.3b (0.7)	—	—
							Eastern New York							
1989	SMP	71.2a (21.0)	8	2.2a (3.3)	0.7a (1.3)	1.8a (2.6)	3.9a (7.2)	1.0a (1.5)	0.9a (1.9)	0.3a (0.6)	—	—	12.3a (9.7)	4.3a (10.2)
	Comparison	73.8a (22.1)	4	1.9a (1.2)	0.3a (0.4)	0.9a (0.3)	3.5a (5.3)	1.9a (1.9)	0.3a (0.5)	0.1a (0.1)	—	—	15.5a (18.8)	1.1b (1.9)

SMP, Simplified Monitoring Program. *tr*, trace (<0.05%). Means in the same column followed by the same letter are not significantly different ($P = 0.05$, least significant difference test [SAS Institute 1985]). Arcsine square-root transformation applied to percentages before analysis.
[a] Number of orchards sampled.
[b] Overwintered generation obliquebanded leafroller.
[c] First summer generation obliquebanded leafroller.
[d] Oviposition scar damage.
[e] Minimal surface damage from either apple maggot or lepidopterous pests.

Table 4. Mean (SEM) number and cost of pesticide sprays applied in SMP and comparison blocks, 1987–1989

Year	Block	n[a]	Fungicides		Insecticides		Acaricides		Total	
			Number[b]	Cost, $/ha	Number	Cost, $/ha	Number	Cost, $/ha	Number	Cost, $/ha
					Western New York					
1987	SMP	19	9.1a (2.3)	175.02a (47.57)	4.7a (2.3)	112.46a (63.22)	1.8a (1.0)	75.03a (39.17)	15.5a (3.5)	349.69a (106.47)
	Comparison	19	8.7a (2.9)	173.17a (49.73)	5.8a (2.1)	150.49b (63.16)	2.4b (1.2)	103.53b (52.40)	16.9a (3.9)	427.19b (109.76)
1988	SMP	19	7.8a (3.0)	194.89a (54.71)	4.9a (2.1)	135.19a (65.30)	1.7a (0.7)	62.76a (34.23)	14.3a (4.4)	392.83a (114.16)
	Comparison	12	8.9a (3.9)	189.16a (73.06)	6.2a (2.3)	162.76a (60.69)	1.8a (0.9)	70.42a (43.92)	17.0a (5.8)	422.34a (134.10)
1989	SMP	19	7.5a (3.7)	244.88a (97.98)	6.3a (2.0)	165.00a (59.85)	1.5a (1.3)	59.80a (59.28)	15.3a (5.7)	469.67a (178.01)
	Comparison	14	9.6a (3.3)	271.13a (110.95)	7.0a (1.2)	189.92a (57.16)	2.0a (1.7)	88.52a (75.34)	18.7b (4.6)	545.18a (182.19)
					Eastern New York					
1989	SMP	6	8.2a (3.7)	241.12a (88.94)	5.6a (2.9)	118.36a (58.76)	0.8a (0.5)	28.26a (18.85)	14.6a (6.4)	387.74a (152.60)
	Comparison	3	8.7a (3.5)	247.91a (95.34)	6.0a (3.1)	150.25a (87.69)	0.9a (0.6)	32.58a (21.81)	15.6a (6.9)	430.74a (190.54)

SMP, Simplified Monitoring Program. Means in the same column followed by the same letter are not significantly different ($P = 0.05$, least significant difference test [SAS Institute 1985]). $\text{Log}_{10}(x + 1)$ transformation applied to values before analysis.
[a]Number of orchards sampled.
[b]Dose-equivalents (rate applied/recommended rate).

was a result of the small number of orchards monitored or if it actually reflects higher population pressures attributable to the close intermixing of abandoned with commercial plantings in this region.

Table 3 reports the results of fruit evaluations for insect and disease injury conducted just before harvest in the SMP participant and comparison orchards in 1987–1989. Fewer comparison blocks than SMP blocks were sampled because it was not always possible to identify conventionally managed plantings on the participants' farms that were generally comparable in terms of fruit variety, tree size, age, and potential pest pressure, or to complete sample evaluations before commercial harvesting operations began. SMP blocks sampled in 1988 included growers taking part in the EASY-MACS expert system validation and those working in association with the private pest consultants in 1989. Also given for 1989 are harvest results from the eight Hudson Valley participants who remained in the program for the entire growing season. Levels of clean fruit in the SMP blocks were lower than in comparison orchards in 1987, primarily because of damage caused by obliquebanded leafroller, which we attributed to improper timing of the summer brood sampling session. Our damage evaluation standards were more stringent than those used in most packinghouses in that fruits exhibiting stings or minute surface pits were counted the same as those with very noticeable damage, whereas such fruit in commercial production would normally be packed out. Although the leafroller damage was unacceptably high in 1987, no SMP participants were penalized monetarily from downgrading of the fruit. Nonetheless, the problem was apparently corrected by sampling at a slightly earlier timing and conducting a follow-up sample in the event of a below-threshold decision. For virtually all other insect and disease categories, there was no significant difference in fruit quality between the SMP and comparison (grower standard) management strategies. Because of regional differences in insect and disease pressure, the 1989 Eastern New York harvest evaluations reflect a greater incidence of fruit spotting caused by white apple leafhopper, *Typhlocyba pomaria* McAtee; and the summer disease complex, which included bitter rot, *Colletotricum gloeo-sporioides* (Penzig) Penzig & Saccardo, sooty blotch, and flyspeck. Neither leafhoppers nor summer diseases were specifically managed in the program.

Examination of SMP participants' spray records at the end of the growing season provided two additional methods of program evaluation. First, we compared the relative numbers of pesticide sprays applied by each grower in their SMP and respective comparison blocks. Application numbers were standardized by transformation into dose-equivalents (DEs), defined as the actual rate per ha applied divided by the rate recommended by university pest management publications (e.g., Wilcox et al. 1987). This procedure addressed any variable applicator practices such as half-rate sprays, alternate row middle sprays, and arbitrary conventions used in concentrating sprays. Approximate cost per ha was calculated by substituting average costs for the products used, as supplied by representative distributors in the region. Results of the spray comparisons are reported in Table 4. In all 3 yr, the number and per-ha cost of fungicides was statistically the same for the SMP and comparison blocks. For western New York in 1987, however, the cost of insecticides and the number and cost of acaricides in comparison blocks were higher than in the SMP blocks, as was the total pesticide cost per ha. In 1989, the number of total DEs was significantly greater in the comparison blocks than in the SMP blocks.

A second aspect of the program reflected by spray records was participants' compliance with the management decisions recommended by pest sampling procedures. Growers' actions for each pest decision were placed into one of four compliance categories: (1) followed recommendation to either apply or withhold a pesticide spray; (2) treated when recommended, but used a nonrecommended pesticide (i.e., a material destructive to predatory mites); (3) did not treat when recommended (pesticide spray was either omitted entirely or applied more than 3 d after the above-threshold sample decision had been obtained); and (4) treated when not recommended. The 3-d spray response time was arbitrarily designated as a period long enough to allow accommodation to other farm duties or weather contingencies, and short enough not to compromise the effective control of most pest problems. A summary of participants' compliance for 1987–1989 is shown in Fig. 2. Overall compliance was highest in general for the indirect pests, particularly spotted tentiform leafminer, for which a 100% rate was attained for both broods by 1989, rosy apple aphid, and early-season European red mite. However, by the third and fourth mite sampling sessions, which took place in later July and August, there were several instances where above-threshold populations were not treated in a timely manner. Also, in some cases, acaricide sprays were applied despite the fact that the late-season thresholds, which are higher than those used earlier in the summer, had not been reached.

Adherence to the trap-based apple maggot recommendations was likewise erratic for a number of the participants. In 1987, when a single catch on an unbaited sphere generated a "treat" recommendation, some growers did not always respond in a timely manner, particularly because traps in the program were checked at least twice a week and many growers were in the habit of addressing the need for apple maggot sprays on a biweekly basis. By 1989, after the threshold had been raised to 5 flies caught per volatile-baited sphere, many blocks never reached a threshold level and some sprays were undoubtedly applied either as a consequence of lack of confidence in the higher threshold or to prevent potential damage by other fruit-feeding pests that are normally controlled by regular apple maggot sprays.

Obliquebanded leafroller generally presented the most problematic management decisions faced by the growers, partly because of the precision needed to time the sampling session correctly and partly because of the difficulty of achieving satisfactory control once a treatable population was documented. There has been a pattern of decrease in the effectiveness of pesticides available to control this pest since its initial description as a problem in New York (Reissig 1978, Reissig & Agnello 1992); therefore, control strategies have tended to become more conservative in recent years. In the mid-1980s, a single spray directed against third and fourth instar larvae would often provide adequate control of the first summer generation, but many commercial growers have come to mistrust thresholds as control failures have become more common after two or even three sprays. Consequently, advice to withhold treatment for small populations is often not heeded, and even sprays against the overwintered generation have increased despite the fact that no correlation has been documented between the two broods in a given orchard.

The extent to which different levels of compliance affected pesticide cost was examined for the 1987 participants. All cooperators were given the same information for determining their pest management needs but if noncompliance is associated with the application of a pesticide spray when it was not recommended, pesticide cost would tend to be higher for those growers. The categories of response to sampling recommendations were assigned values in increasing order of noncompliance (categories 1–4, as described above); therefore, the total "score" for all the pest management decisions made during the year provided a numerical index of compliance. A "1", signifying that recommendations were followed for each of the 11 sampling sessions would give a "perfect" score of 11 for the season. The scores of the 19 participants were distributed around three mean values: the top 4 (average compliance, 13.0), the middle 11 (16.0), and the bottom 4 (25.3). Their respective pesticide costs per ha (per acre) averaged $299.22 ($121.14), $344.86 ($139.62), and $435.14 ($176.17), respectively, indicating a potential correlation between compliance and pesticide use.

The evaluation questionnaire administered after the 1987 season provided both objective and interpretive details of participation by the program's users. Of the 21 respondents, 62–86% correctly answered questions about spotted tentiform leafminer sampling procedures, and 59–62% correctly answered questions pertaining to the pest's biology. However, only 28–52% correct responses were obtained for obliquebanded leafroller sampling and biology questions. In contrast, 90–100% of the respondents correctly answered various questions about European red mite. Questions regarding apple maggot biology and trap placement elicited 57–71% correct responses, but 86–100% of the respondents understood the specifics of checking the traps and adhering to the threshold. Participants' confidence in their ability to correctly implement the sampling procedures after being instructed were lowest for obliquebanded leafroller and highest for apple maggot. Confidence in treatment decision information provided by sampling also was lowest for leafrollers and highest for apple maggot (referring to the threshold of a single fly caught on an unbaited red sphere.) More than half of the respondents said that information they obtained sampling these pests influenced their control strategies on the rest of the farm, and an additional one-third admitted that they might have been influenced "subconsciously" by their sample results. Among reasons given for not always following the program's advice were: a need for some "insurance" sprays (44% of respondents); lack of confidence in the recommendation given (31%); decision to follow someone else's advice instead (25%); and lack of concern about the pest (13%). When asked to rate the likelihood of

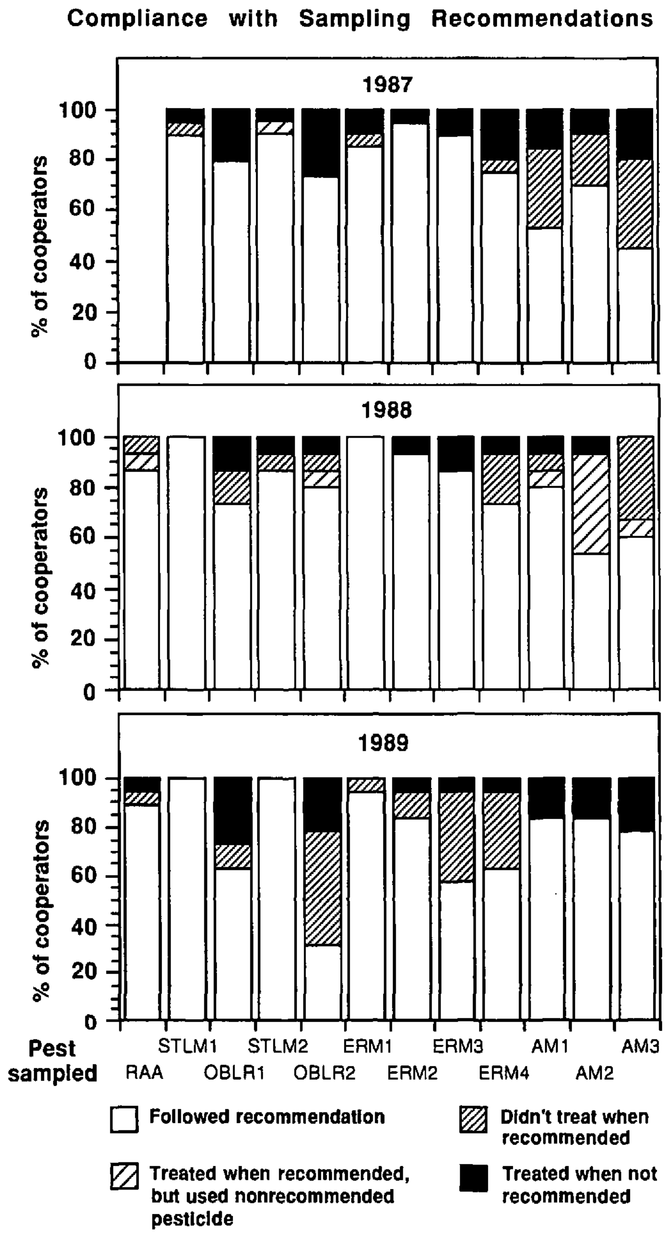

Fig. 2. Compliance of participants in SMP with program recommendations. RAA, rosy apple aphid. STLM1, first generation spotted tentiform leafminer. OBLR1, overwintered generation obliquebanded leafroller. STLM2, second generation spotted tentiform leafminer. OBLR2, first summer generation obliquebanded leafroller. ERM1–4, European red mite sampling sessions. AM1–3, apple maggot monitoring periods.

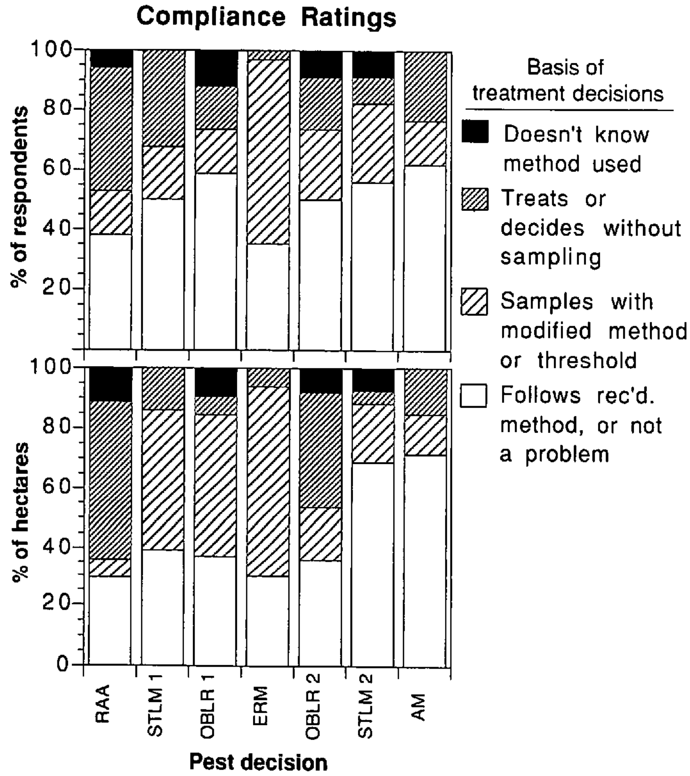

Fig. 3. Basis of management treatment decisions made by SMP participants on their apple farms, according to a 1991 survey. RAA, rosy apple aphid. STLM1, first generation spotted tentiform leafminer. OBLR1, overwintered generation obliquebanded leafroller. ERM, European red mite. OBLR2, first summer generation obliquebanded leafroller. STLM2, second generation spotted tentiform leafminer. AM, apple maggot.

using the sampling procedures and treatment guidelines on their own if the information could be distributed in other ways, the participants responded affirmatively to weekly newsletters (75%), the annual tree-fruit production guide (65%), a combination of printed materials and one or two field sessions (100%), and personal computer programs (45%). Finally, when told to assume that the SMP procedures represented the minimum effort growers needed to invest to make their own scouting decisions, and if confidence in their ability to perform them was not an issue, 82% of the participants said they would consider paying someone else to conduct these procedures for them because of the time and effort required.

1990. There was variable grower compliance with the summer pest sampling recommendations for the four blocks being overseen by a private consultant in Ulster County. In one orchard, the grower complied fully with "no-treat" recommendations for obliquebanded leafroller, spotted tentiform leafminer, and European red mite, and the three pesticide sprays recommended for apple maggot control. Compliance was mixed in the remaining three orchards; first, leafrollers were below threshold in all three, but one grower applied a spray nonetheless. None of these three orchards received a spray for second generation spotted tentiform leafminer, but an actual "no-treat" decision was obtained in only one case; in the other two blocks, sampling was discontinued before a decision could be made (i.e., the sequential sampling tally was still in the "continue sampling" zone). For European red mite, acaricides were neither recommended nor applied in one case, but early-summer "treat" decisions were ignored in the remaining two blocks, which may have mitigated the effectiveness of later sprays that were applied when recommended. "Treat" decisions for apple maggot received the greatest level of compliance although they were not properly timed in two orchards, being too late in one case and too frequent in another (five sprays were applied during the trapping period when only four were recommended). Moreover, apple maggot traps were not generally monitored frequently enough—in some cases, less than once per week—to maintain an accurate record of adult populations.

Spray records indicated that an average 14.9 DEs of all types of pesticides were applied in the four SMP blocks, and comprised averages of 8.0 fungicide, 5.6 insecticide, and 1.3 acaricide DEs. Costs of these crop protectants per ha averaged $199.28 for fungicides, $136.29 for insecticides, and $44.26 for acaricides, or $379.83 total. All of these values are comparable to those generated for SMP participants during demonstrations of the previous 3 yr.

The EASY-MACS expert system field validation progressed in small increments. Continuous seasonal recommendations and data collection were not possible because of the ongoing nature of the software development process, but modifications of its operating system were incorporated as a result of exposure to more typical management situations for implementation in subsequent seasons. Respondents of the fall EASY-MACS survey included apple growers, Cooperative Extension agents, and apple pest researchers. A total of 73 survey responses were returned from people who had purchased the EASY-MACS program, of which 27 were New York residents; 24 of these people were apple growers and the remaining 3 had occupations in research or extension. The 46 purchasers outside of New York included 25 growers. Only a small number of people who bought the system (for a nominal fee) actually installed and attempted to use it (six growers and four extension agents) and only one extension agent maintained its operation for the entire season. Responses indicated primary difficulties with EASY-MACS' requirements for computer disk space, internal memory, or specific operating systems. Users with adequate personal computer setups cited insufficient program breadth or detail to justify the time investment needed to properly run the system for the entire season.

1991, Expert System. Cool and wet spring weather produced a total of nine primary apple scab infections in most parts of the region. For the 10 commercial orchards running EASY-MACS, incidence of fruit scab at harvest was high (15.6%) in only 1 orchard using the DMI fungicide program, possibly as a result of insufficient application rates; fruit scab averaged 0.4% (range, 0–2.2) in the remaining orchards. Fungicide DEs applied during the season averaged 7.9. The largest amount of insect pest damage was caused by obliquebanded leafroller; fruit damage was >10% in two orchards and averaged 2.5% (range, 0.2–7.8) in the remaining eight blocks. An average total of 5.8 (range, 3.7–9.2) insecticide DEs were used overall. Hot, dry weather during the remainder of the season encouraged rapid European red mite population growth, and the average of 2.5 acaricide DEs used in these blocks were not generally effective; foliar bronzing from mite feeding was noted in 8 of the 10 orchards. There was an average of 92.2% (range, 76.2–99.4) clean fruit from all the blocks participating in this program. Total per-ha pesticide costs for these blocks averaged $587.51 (range, $374.80–732.18) with average costs for fungicides, insecticides and acaricides at $289.39 ($205.48–348.25), $186.83 ($131.50–267.85), and $111.30 ($22.38–191.43), respectively.

Field evaluation of the EASY-MACS system was generally helpful in identifying problems for correction in subsequent versions. Specific portions of the software were designated as requiring the most attention, according to the amount of user interaction they entailed. These included the program portions having to do with tree development and trap catch data, weather data, pest abundance, and pesticide use records.

1991, Survey. Of the 35 people interviewed, 17 had participated in the SMP program for 3 yr, 3 for 2 yr, and the remaining 15 were single-year participants. One of the most revealing trends was that only 15 of the respondents were the sole providers of pest sampling information for their farm; an additional 14 conducted some of their own sampling, but relied on a private consultant for maintenance of regular and complete pest monitoring activities. The remaining six growers had turned over pest sampling responsibilities completely to a private consultant and did no monitoring on their own. These trends were independent of the number of years of participation in the program. In only one case, however, did the grower also completely entrust the management treatment decision process to the consultant; all the other respondents exercised either ultimate (73%) or participatory (27%) authority with the consultant over treatment decisions. Also, although the scouting manual had been modified annually since 1987 to incorporate refinements in the sampling procedures, nearly all of the participants were still referring to the edition they were provided during their most recent year of participation, which in some cases was 1988. Despite an acknowledged incomplete understanding of the biological fundamentals underlying the pest sampling procedures, 54% of the respondents stated that they had read the manual's brief discussion of these details only once, upon initially receiving the manual when they started the program, and 17% said they had never read it.

Survey participants were questioned about the extent to which they currently used recommended sampling procedures as a basis for their control decisions regarding the SMP key arthropod pests. For each of the major treatment decisions addressed in the program, each grower's approach was classified in one of four ways: (1) either follows the recommended method or the pest is not a problem; (2) samples before deciding, but uses a modified procedure or threshold; (3) treats or decides on the need for a treatment without sampling; or (4) doesn't know what method is used to determine the need for a treatment. Fig. 3 reports the results of these compliance ratings expressed as the percentage of cooperators and acreage represented by each category. A small number of respondents, primarily those employing private consultants, were uncertain of the methods used to determine treatment decisions for rosy apple aphid, obliquebanded leafroller, and summer generation leafminer. Treatment decisions made without relying on sampling information were most prevalent for rosy apple aphid, first generation leafminer, summer generation leafroller, and apple maggot. More than half of the respondents used the recommended sampling or monitoring procedures for leafminer, overwintered brood leafroller, and apple maggot, which in the case of apple maggot and summer leafminer corresponded to ≈70% of the acreage represented. The most intensively sampled pest was European red mite although there was a broad range of compliance with the sampling procedures and thresholds employed. Only 11% of the respondents stated that they scouted for insects without the aid of a magnifying device of some sort, but fewer than half (46%) maintained any written records of pest sampling results and a number of these constituted only partial documentation. No personal computers were used in the farm operations of 57% of the growers questioned and the majority of those computers in operation were used exclusively for functions unrelated to aspects of crop production or protection, such as payroll management and sales records.

Supplementary comments made by survey respondents provided some additional perspectives on the specific pest decisions faced by these growers. The relatively poor compliance evidenced for rosy apple aphid and leafrollers can probably be attributed to the level of difficulty of the sampling procedure itself or else the occasionally poor prospects for acceptable control. For rosy apple aphid, growers tended not to trust the low threshold because the insects could easily be misidentified or unnoticed entirely; thus, they were hestitant to believe that a "zero-count" truly indicated the absence of a treatable population. Growers who had high leafroller populations in the past tended to assume problems would recur every year, potentially in every block on their farm, so they felt justified in making prophylactic sprays, often as early as possible in the spring and summer "just to be sure." Some growers reported using the sampling procedure after treating to evaluate the spray's effectiveness. Only 17% used pheromone traps as an aid in sampling or scheduling their leafroller sprays, and 24% had tried a *B. thuringiensis* material as of the date of the survey, although use of these products has subsequently become more widespread.

There was some belief among respondents that problems from spotted tentiform leafminer were related to unproven or disproven factors such as presence or absence of high populations in a block during previous years or previous broods of the same year, problems in someone else's orchard, or high numbers of adults caught in pheromone traps. None of the respondents used trap catches to schedule summer sampling sessions, and 12% had tried diflubenzuron, a selective insect growth regulator, when it had been available in certain years. For European red mite control, 80% of the growers reported that they used a delayed dormant petroleum oil application on all of their acreage and 8.6% stated they used oil on <25% of their acreage. Although most stated an intention to conserve predatory mite populations by using selective pesticides as much as possible, there was little hesitation expressed in relying on a pyrethroid for control of early-season pests such as tarnished plant bug, rosy apple aphid, and leafminers. Many of the growers departed from the summer mite sampling protocol if a decision could not be reached after the first 25–35 leaves were sampled; they generally felt that a reasonable treatment decision should be possible by this point and did not wish to invest additional time to arrive at what they felt to be the logical conclusion (usually, to treat). Some of this conservative attitude is understandable considering the increasing trend of mite control problems in U.S. apple production systems, which is attributable to acaricide resistance development and a reduction in the number of products available for effective control. However, even some of the most progressive growers dismissed the threshold concept entirely when dealing with mites because in their experience, even small numbers of mites on the foliage too frequently developed into uncontrollable populations. A relatively high proportion (21%) of the respondents had experimented with summer applications of highly refined petroleum oils, which at the time was not a well-documented or widely recommended practice.

Although 80% of the participants regularly used red plastic sphere traps to monitor apple maggot flies on their farms, most did not employ the modification of adding an apple volatile lure and using the 5-per-trap treatment threshold. Many expressed a disbelief in the safety of the higher threshold, and some felt that the volatile lure attracted flies from other areas. A few growers maintained the traps in their orchard just to observe the flight trends, but used block history or calendar spray schedules instead of trap catches as a basis for their treatment decisions.

Discussion

Our primary intention was to assess both the biological and economic outcomes of specific apple IPM programs, particularly those administered over the course of several years. These analyses tended to demonstrate that benefits do accrue over the long term, but the programs often have the same short-term material costs as do conventional approaches and generally require an increased expenditure of time and effort by the participant. Consequently, program evaluations are sometimes interpreted by policy makers as evidence of fruit growers' nonacceptance when, in fact, these programs are simply reflecting the difficulty of making large changes to long-held practices. Similarly, extension field staff are occasionally criticized for failing to promote some of the proposed technology, but these criticisms are usually a result of mistaking slow progress for no progress. Comparable observations on selective technology adoption by fruit growers have been made by Lambur et al. (1985) and Ridgley & Brush (1992).

Our findings have tended to support the speculation of Corbet (1981) that even if growers were sufficiently well informed to make pest damage and treatment assessments, and even if they always complied with recommended guidelines, most would be unable to properly implement an IPM program because of the many demands placed on their time. The SMP participants expressed universal appreciation of the program's role in providing them with greater confidence in their ability to detect pest problems and a better understanding of the specifics of pest treatment decisions. However, after discerning that the benefits of a rather involved sampling regimen could not always be given a dollar value, most felt justified in distancing themselves from the technical details of the procedures on their own farms, if they continued using them at all. This would be an acceptable outcome if it automatically resulted in a greater reliance on the scouting services of private consultants, but this sector has so far been unable to take advantage of any increased appreciation of a comprehensive scouting program, primarily because of the increased labor costs of such a service.

Some authors reporting on field demonstration programs in cotton (Boutwell & Smith 1981, Douce et al. 1983, Thomas et al. 1990) have cited a relationship between the amount of IPM methodology used and increased crop yield. In our programs, evaluations of an analagous measurement for a perennial crop (i.e., decreased fruit injury) have not exhibited a similar relationship, perhaps because of the breadth and diversity of arthropod pest pressures in New York apple systems. Our results are generally in line with those of previous studies that found negligible differences between IPM and conventional pest control systems in pesticide cost and overall production profit (Hall 1977, Boutwell & Smith 1981, Douce et al. 1983). Although less was spent for pesticides in the SMP program one year and, in another, fewer total sprays were applied, this does not appear to be a constant trend, but rather a variable influenced by seasonal and regional differences in pest pressure. More importantly, the comparison blocks in these trials cannot be considered actual controls because of the nature of the experimental design. There were no standardized treatments administered in those blocks and no data collected from them until the end of the season. The results of using our alternative management strategy were compared with those of a more conventional approach primarily as a matter of general interest. A more ideal arrangement would have been to contrast the different pest management programs in one-half of the same block, but this was not possible because of the logistical complexities it would have posed for the growers.

In the absence of any clear economic incentive for implementing labor-intensive sampling procedures, there is currently little demand being generated by New York apple growers for such a service. Private consultants ultimately justify their fee by the amount of savings they can realize for their clients; therefore, it is unrealistic to expect them to modify their monitoring practices solely to remain current with new IPM techniques being developed by the public sector (i.e., universities). Discussions of the economics of IPM implementation often address the desirability of a market premium for commodities produced by growers employing IPM methodology. However, a recent study in New York uncovered considerable sentiment against the establishment of a grower IPM certification program from the market sector as well as among the various grower groups (Grant et al. 1990). In a previous grower survey of the incentives for adoption of IPM methods (Wearing 1988), cost advantage was perceived to be more important overall than concerns such as pesticide resistance, environmental issues, and grower hazard associated with more conventional approaches.

The development of the EASY-MACS expert system was characterized by several changes of approach and subsequent design reconstructions to evaluate the program's utility. Changes included the style of user interface, the management of data and recommendations, and the program's evolution from a single-block to a whole-farm management tool (McInnis et al. 1990, 1992). Unfortunately, despite the relatively advanced state of EASY-MACS' development and the responsiveness of its support personnel, there has been a continual decline in the availability of resources necessary for system maintenance and modification. Together with the relatively limited use of personal computers in commercial apple operations, this lack of support has relegated further exploration of expert systems in New York fruit pest management to some undetermined future date.

In conclusion, the current situation in fruit pest control nationwide may be likened to the difficult scenario of Whalon & Croft (1984) in which a change in technology is available that would significantly improve the system, but in which no crisis actually exists to provide an impetus for change. A primary emphasis of New York's fruit IPM program has been the correct timing and justification of pesticide use (Tette et al. 1979). The detailed guidelines produced so far are arguably as thorough and reliable as those of some European systems where government intervention and social demand are combining to promote more aggressive incorporation of this technology (Oberhofer 1991). Such an achievement appears to be unlikely in this country without the influence of some comparable motivating force, whether it be economic or regulatory. After five years of efforts to assess the IPM adoption process in New York apple production, it is gratifying that a substantial amount of information has begun to be implemented by growers despite significant constraints and countervailing arguments. The basic SMP procedures and recommendations have been incorporated into the state's tree-fruit production guide (Wilcox et al. 1993) and most growers have adopted at least portions of the technology they feel are suited to their needs. The majority of our cooperators appreciated receiving in-depth information on insect and mite scouting, but generally do not have the time, interest, or patience to do the scouting themselves. Those who do scout often modify the technique or threshold recommended and most do not maintain written sampling records. They are more likely to prefer alternative spray materials to methods that may ultimately recommend against spraying. The lack of an economic incentive to implement such techniques will continue to be a primary factor mitigating against more complete IPM adoption.

Acknowledgments

We thank private consultants S. Acampora and J. Alicandro; Cornell Cooperative Extension Agents F. Dellamano, F. McNicholas, J. Mishanec, W. Smith, and C. Telgheder; K. Morse and M. Burlee, AgChem Service, for their cooperation in administering certain portions of this program; and we are grateful to all the growers and consultants who cooperated as participants. We also thank Cornell Technical Assistants A. Grabb, S. Green, K. Kirchhoff, and J. Minns for their field skills. Special thanks go to Department of Entomology Research Assistants B. Huber, P. McInnis, Jr., and W. Wolf, for their tireless work on the EASY-MACS expert system, and to G. Palmer, Cornell Media Services, for his cooperation in producing the video. This project was primarily supported by funds from the New York State Department of Agriculture and Markets, Albany.

References Cited

Agnello, A. M. & J. Kovach. 1989. Simplified insect management program: a video for apple sampling procedures in New York. Cornell Media Services, Ithaca, NY.

Agnello, A. M., J. Kovach, J. Nyrop & H. Reissig. 1989. Simplified insect management program: a guide for apple sampling procedures in New York. Cornell Integrated Pest Management Bull. 201A, Geneva.

1990b. Simplified insect management program: a guide for apple sampling procedures in New York. Cornell Integrated Pest Management Bulletin 201A, Geneva, NY.

Agnello, A. M., J. Kovach, J. Nyrop, H. Reissig & W. Wilcox. 1991. Simplified insect management program: a guide for apple sampling procedures in New York. Cornell Integrated Pest Management Bulletin 201C, Geneva. NY.

Agnello, A. M., S. M. Spangler & W. H. Reissig. 1990a. Development and evaluation of a more efficient monitoring system for apple maggot (Diptera: Tephritidae). J. Econ. Entomol. 83: 539–546.

Antle, J. M. 1988. Integrated pest management: It needs to recognize risks, too. Am. Agric. Econ. Assoc. 3: 8–11.

Boutwell, J. L. & R. H. Smith. 1981. A new concept in evaluating integrated pest management programs. Bull. Entomol. Soc. Am. 27: 117–118.

Chapman, P. J. & G. W. Pearce. 1949. Susceptibility of winter eggs of the European red mite to petroleum oils and dinitro compounds. J. Econ. Entomol. 42: 44–47.

Corbet, P. S. 1981. Non-entomological impediments to the adoption of integrated pest management. Prot. Ecol. 3: 183–202.

Dennehy, T. J., J. P. Nyrop, W. H. Reissig & R. W. Weires. 1988. Characterization of resistance to dicofol in spider mites (Acari: Tetranychidae) from New York apple orchards. J. Econ. Entomol. 81: 1551–1561.

Douce, G. K., D. K. Linder, M. E. Wetzstein & W. N. Musser. 1983. Evaluating extension integrated pest management programs with factor analysis indices. Bull. Entomol. Soc. Am. 29: 43–46.

Glass, E. H. 1975. Recent developments in deciduous orchard pest management in the United States. EPPO Bull. 5: 101–111.

Goodell, G. 1984. Challenges to international pest management research and extension in the Third World: Do we really want IPM to work? Bull. Entomol. Soc. Am. 30: 18–26.

Grant, J., J. Tette, C. Petzoldt & J. Kovach. 1990. Feasibility of an IPM-grower recognition program in New York State. Cornell Univ. IPM Bulletin 3.

Gruys, P. 1982. Hits and misses: the ecological approach to pest control in orchards. Entomol. Exp. Appl. 31: 70–87.

Hall, D. C. 1977. The profitability of integrated pest management: Case studies for cotton and citrus in the San Joaquin Valley. Bull. Entomol. Soc. Am. 23: 267–274.

Huber, B., J. P. Nyrop, W. Wolf, H. Reissig, A. Agnello & J. Kovach. 1990. Development of a knowledge-based system supporting IPM decision making in apples. Comput. Electron. Agric. 4: 315–331.

Lambur, M. T., M. E. Whalon & F. A. Fear. 1985. Diffusion theory and integrated pest management: Illustrations from the Michigan fruit IPM program. Bull. Entomol. Soc. Am. 31: 40–45.

McInnis, P. J., Jr., J. P. Nyrop & W. A. Wolf. 1990. Agricultural decision support system design; the evolution of EASY-MACS, pp. 329–334. *In* Proceedings 3rd International Conference on Computers in Agricultural Extension Programs, American Society of Agricultural Engineers, Orlando, FL.

1992. Programming environment needs for pest management decision support systems, pp. 694–699. *In* Proceedings 4th International Conference on Computers in Agricultural Extension Programs, American Society of Agricultural Engineers, Orlando, FL.

Mumford, J. D. & G. A. Norton. 1984. Economics of decision making in pest management. Annu. Rev. Entomol. 29: 157–174.

Nowak, P. 1991. Farmer adoption of production technologies, pp. 31–33. *In* Proceedings Crop Residue Management for Conservation Conf.

Nyrop, J. P., A. M. Agnello, J. Kovach & W. H. Reissig. 1989. Binomial sequential classification sampling plans for European red mite (Acari: Tetranychidae) with special reference to performance criteria. J. Econ. Entomol. 82: 482–490.

Nyrop, J. P., W. H. Reissig, A. M. Agnello & J. Kovach. 1990. Development and evaluation of a control decision rule for first-generation spotted tentiform leafminer (Lepidoptera: Gracillariidae) in New York apple orchards. Environ. Entomol. 19: 1624–1638.

Oberhofer, H. 1991. Integrated fruit production in South Tyrol, pp. 53–62. *In* Proceedings, 136th Annual Meeting. New York State Horticultural Society, Rochester, NY.

Onstad, D. W., W. H. Reissig & C. A. Shoemaker. 1985. Phenology and management of the obliquebanded leafroller (Lepidoptera: Tortricidae) in apple orchards. J. Econ. Entomol. 78: 1455–1462.

Prokopy, R. J. & K. I. Hauschild. 1979. Comparative effectiveness of sticky red spheres and Pherocon AM Standard Traps for monitoring apple maggot flies in commercial orchards. Environ. Entomol. 8: 696–700.

Reissig, W. H. 1978. Biology and control of the obliquebanded leafroller on apples. J. Econ. Entomol. 71: 804–809.

Reissig, H. & A. Agnello. 1992. Management of the obliquebanded leafroller and the use of summer oil against the European red mite. 121st Annual Report Michigan Horticultural Society.

Ridgley, A. M. & S. B. Brush. 1992. Social factors and selective technology adoption: the case of integrated pest management. Human Organization 51: 367–378.

Sarette, M., J. P. Tette & J. Barnard. 1981. SCAMP—A computer-based information delivery system for Cooperative Extension. N.Y. Food Life Sci. Bulletin 90, Geneva, NY.

SAS Institute. 1985. SAS user's guide: statistics, version 5 ed. SAS Institute, Cary, NC.

Schmaedick, M. 1993. Sampling arthropod pests with uncertain phenology: a cascaded sequential sampling plan for spotted tentiform leafminer. M.S. thesis. Cornell University, Ithaca, NY.

Stiles, W. C., A. M. Agnello, W. F. Wilcox & J. Kovach. 1991. 1991 pest management recommendations for commercial tree-fruit production. Cornell University Press, Ithaca, NY.

Tette, J. P., E. H. Glass, D. Bruno & D. Way. 1979. New York tree fruit pest management project 1973–1978. New York State Food Life Sci. Bull. 81.

Tette, J. P., J. Kovach, M. Schwarz & D. Bruno. 1987. IPM in New York apple orchards—development, demonstration, and adoption. New York State Food Life Sci. Bull. 119.

Thomas, J. K., H. Ladewig & W. A. McIntosh. 1990. The adoption of integrated pest management practices among Texas cotton growers. Rural Soc. 55: 395–410.

Wearing, C. H. 1988. Evaluating the IPM implementation process. Annu. Rev. Entomol. 33: 17–38.

Weires, R. W., J. R. VanKirk, W. D. Gerling & F. M. McNicholas. 1985. Economic losses from the tarnished plant bug on apple in eastern New York. J. Agric. Entomol. 2: 256–263.

Welty, C., W. H. Reissig, T. J. Dennehy & R. W. Weires. 1987. Cyhexatin resistance in New York populations of European red mite (Acarina: Tetranychidae). J. Econ. Entomol. 80: 230–236.

Whalon, M. E. & B. A. Croft. 1984. Apple IPM implementation in North America. Ann. Rev. Entomol. 29: 435–470.

Wilcox, W. F., A. M. Agnello, J. Kovach & W. C. Stiles. 1987. 1987 Cornell chemical recommendations for commercial tree-fruit production. Cornell University Press, Ithaca, NY.

1993. 1993 pest management recommendations for commercial tree-fruit production. Cornell University Press, Ithaca, NY.

Wilcox, W. F., D. I. Wasson & J. Kovach. 1992. Development and evaluation of an integrated, reduced-spray program using sterol demethylation inhibitor fungicides for control of primary apple scab. Plant Dis. 76: 669–677.

Received for publication 14 July 1993; accepted 18 October 1993. ◆

Arthur Agnello and Jan Nyrop are associate professors and Harvey Reissig is a professor in the Department of Entomology, New York State Agricultural Experiment Station, Geneva 14456-0462. Joe Kovach is the Fruit IPM Coordinator, Integrated Pest Management Program, and Wayne Wilcox is an associate professor in the Department of Plant Pathology, also located at the Geneva Station. Deborah Breth is an Area Extension Specialist in fruit pest management with Cornell Cooperative Extension, 20 S. Main St., Albion, NY 14411.