Building a Pheromone-based Multi-tactic Pest Management System for Western Orchards

2003 Areawide II Demonstration Project
Year-end Report
Washington State

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Abstract (summary)

Apples:

Both SOFT and CONV treatment regimes were able to maintain injury from codling moth (CM) at a very low level across the AWII project, even in the face of increasing CM pressure throughout most of the growing areas of Washington state. CM pressure varied in the AWII project from low-moderate in most blocks to high at two of the orchards (A3 and A5). On average, there was no real change in CM injury in either treatment regime from 2001-2003 as measured at harvest by bin samples. The average number of insecticide applications and the total cost of insecticides were very similar between the two treatment regimes. Specifically, the average insect control cost of the SOFT program was slightly higher than the CONV program in year-one (SOFT- $183/a, CONV- $151/a in 2001) but was lower or the same in the last two years (SOFT- $170/a, CONV- $175 in 2003). There were no unexpected increases in pest problems from secondary insects in either the OFT or CONV treatments at any orchard. Secondary pest populations were low in all orchards as was the level of injury to fruit at harvest. Monitoring of CM, leafrollers and *Lacanobia subjuncta* provided growers with information needed to respond with well-timed control measures. It was apparent after three years of the AWII that in most situations a pheromone-based pest management program that relies on SOFT insecticides for both CM and leafroller control with supplemental Assail applications for CM is competitive with CONV regimes in cost and fruit protection.

Pear:

2003 is considered the second year of the AWII pear project, as a different experimental design was adopted in 2002. This limits conclusions about the overall effect on biodiversity of SOFT programs, as it may take more time for populations to respond to insecticide modifications. However, what was clear that even under conditions of increased codling moth and pear psylla pressure throughout the entire project (as measured by harvest injury evaluations) a SOFT treatment regime, based on insect growth regulators and Surround can maintain fruit quality equivalent to a CONV program based on organophosphates and specific psyllacides and miticides. Further, this program was sustainable over the two years of the project. A limiting factor to the full implementation of the SOFT program described in this report will be the economic concern of increased pesticide applications and increased cost associated with the some of the SOFT insecticides, specifically Surround and azadirachtin. After year two of the project the SOFT program remained slightly more expensive than the CONV program (2001- SOFT $355/a, CONV $335/a; 20002- SOFT $401/a, CONV $355/a). It remains to be seen if the cost differential decreases as biological control agents for PP are expected to increase in response to a SOFT program. However, after two years there has been no significant advantage in increased natural enemy densities to the SOFT control program over the CONV program. One other concern of the SOFT treatment regime is a notable lack of suitable insecticides for pear rust mite control, which may be a limiting factor in industry-wide implementation of the SOFT principals promoted by this project. However the concerns albeit justified are limited and many growers will be able to benefit from the experiences developed in AWII.

Areawide II Demonstration – 2003 Report

Two grants supported by the USDA-CSREES were funded through the Initiative for Future Agriculture and Food Systems (IFAFS) and FQPA Risk Mitigation for Major Food Crop Systems (RAMP) programs. The grant titles were "Building a multi-tactic pheromone-based pest management system in western orchards" for the IFAFS grant and "Enhancing pheromone mating disruption programs for lepidopterous pests in western orchards" for the RAMP grant. These grants were funded through Washington State University (IFAFS) and University of California, Berkeley (RAMP) with subcontracts to participating institutions and agencies.

A primary goal of the IFAFS/RAMP funded project was to stabilize and extend codling moth mating disruption (CMMD) to 75% of the pome fruit and 25% of the walnut acreage in WA, OR and CA. Washington State University implemented a demonstration project, Areawide II (AWII), which was evaluating CMMD programs that replace supplemental organophosphate controls with selective insecticides (e.g. oils, IGRs, particle film, microbials, neo-neurotoxins). Grower experience in using these pest control tools has been limited either by perceptions that the approaches are too risky or because they are new (recently registered). AWII compared a "novel" pest control program using only selective ("SOFT") insecticides with a conventional ("CONV") program that allowed for the use of organophosphate (OP) or carbamate insecticides. AWII contrasted the relative efficacy and economic value of the novel programs.

EXPERIMENTAL DESIGN

The initial step to implementing the AWII demonstration project was to establish apple and pear study sites covering at least 400 acres of apple and 100 acres of pear in Washington State. The corner stone of the management program was to have CMMD applied to the entire area at each site as part of the grower's normal practice. Two supplemental treatment regimes were standardized for each study site, a CONV regime using broad-spectrum insecticides plus CMMD and a SOFT regime using selective insecticides plus CMMD (Appendix 1a-Apple, Appendix 2a-Pear). The SOFT treatment regime specifically eliminated the use of all OPs while striving for the elimination of carbamates (including carbaryl traditionally used as a thinning agent for apples), chlorinated hydrocarbons and synthetic pyrethroid insecticides. Products available included but were not limited to *Bacillus thuringiensis* (e.g. Dipel WDG, Javelin), methoxyfenozide (Intrepid), spinosad (Success), horticultural mineral oil, imidacloprid (Provado), indoxacarb (Avaunt), pyriproxyfen (Esteem), and particle films (Surround). The SOFT treatment regime was flexible and changed from year to year as newly registered products became available or as pest densities were lowered to the point that the softest alternative replaced more disruptive insecticides.

The experimental design was a series of side-by-side comparisons (CONV vs. SOFT) of at least 10 acres/treatment, replicated across several sites (Table 1). General pest monitoring was conducted at each study site using protocols developed in the CAMP study. Pests monitored included CM, leafrollers (LR), *Lacanobia subjuncta* (LAC), white apple leafhoppers (WALH), western tentiform leafminer (WTLM), *Campylomma* *verbasci*, spider mites, aphids, pear psylla (PP), and grape mealybug (GMB). These arthropods were selected for specific monitoring activity because they represented key pest groups that reflected the efficacy of different treatment regimes as well as the impact these regimes had on the natural enemy complex. A pest control advisor was selected to work with growers at each study site to manage pest control programs, collect treatment records and assist a state coordinator, USDA-Wapato and WSU-TFREC personnel in collecting pest and beneficial insect data. Pest densities were monitored using traps, foliage samples and visual examinations following established protocols. The pest impact was evaluated by examining fruit at the end of the first CM generation and again at harvest for damage in each treatment regime. Study sites were compared for trends in data over time. Cost data and crop damage was analyzed to determine the overall impact of the treatment regimes on grower profitability.

MONITORING (Apple)

A wide array of tools was used to monitor lepidopteran pests. Adult CM were monitored with large delta-style sticky traps baited with a high-load pheromone lure (SuperLure, Phero Tech, Inc.) and similar traps baited with a kairomone attractant (DA lure, Trécé, Inc.). CM traps were used at a density of one pheromone and one DA baited trap per 2-2.5 acres. Both pandemis (PLR) (*Pandemis pyrusana*) and obliquebanded (OBLR) (*Choristoneura rosaceana*) leafrollers were monitored using delta-style sticky traps baited with a standard (1X) and low load (0.1X for PLR, 0.05X for OBLR) pheromone lures, with one lure of each type being placed in a trap in each treatment-block. Adult LAC were monitored with a general purpose, plastic bucket style trap (Phero Tech, Inc.) baited with a standard-load pheromone lure (Suterra, Inc.) at a density of one per treatment-block. All traps were checked weekly and the number of moths recorded. CM adults in the DA Lure baited traps were collected and returned to WSU-TFREC for identification, counting and determination of sex and mating status. The SuperLures, LR pheromone lures, and LAC pheromone lures are changed every 6 weeks. The DA lures are changed every 8 weeks.

Field monitoring for fruit and foliage damage was done at key times throughout the season in each orchard. Surveys were made in each block for the amount and location of damage by each of the lepidopteran pests. LR damage was surveyed in late May and early August. Damage by CM and LAC was evaluated in early to mid July, and CM damage was evaluated again prior to harvest. Further, fruit were inspected in bins during harvest for damage from lepidopteran pests and other insects.

Specific secondary pest and natural enemy density samples were made using protocols developed in the CAMP study. The following samples were made: overwintering WALH eggs for egg density and parasitism; *C. verbasci* nymphs during bloom; WALH nymphs (1^{st} and 2^{nd} generation); green aphid complex and associated natural enemies (once each in June, July, and August); mites (tetranychid, rust, and predatory) once each in June, July, and August; WTLM (mine density during the latter part of the 1^{st}, 2^{nd} and 3^{rd} generation mines) and parasitism estimates on those blocks with sufficient mines present; fruit damage/presence of secondary pests before harvest (adult mite and egg calyx infestation, aphid honeydew and leafhopper tarspotting); and *C. verbasci* adults in pheromone-baited traps.

Pear

Leptidopteran pests were monitored essentially the same in the pear test sites as in the apple. The kairomone used in the DA Lure is a pear ester and was shown to have reduced attractiveness to CM in pear orchards. Therefore, DA lure use was discontinued in pears during 2003. LAC is not a major pest in pear and thus was not monitored in this project. Every two weeks, the pear orchards were monitored separately for pear pests and natural enemies by limb-tap sampling. Spur (prebloom) and leaf samples (mid-May through August) were also collected at two-week intervals. These leaf samples were brushed using a standard mite-brushing machine and counted at WSU-TFREC. All key pest and beneficial arthropods were counted during the limb-tap and leaf-brush sampling periods. Fruit and foliage damage assessments are made using the same methods as the apple orchards.

2003 RESULTS (Apple)

Codling moth:

To assess the efficacy of the experimental treatment regimes it was important to first understand the level of CM pressure each orchard was experiencing at the onset of the demonstration project. A wide range of CM densities, as measured by first generation trap captures, were present within the 15 AWII apple sites. In the first generation of 2001 CM pheromone traps average 7.0 (SOFT) and 4.0 (CONV) moths/trap and ranged from an average of 0-52 moths/trap for the season.

The ultimate measure of a CM management program is the suppression of fruit injury. At the mid-year assessment CM damage was detected in only 2 of the SOFT blocks and 4 of the CONV blocks (Table 2a). Only the SOFT block in orchard A5 had more than one CM damaged fruit out of at least 1000 sampled apples. Overall, average CM injury between SOFT and CONV blocks was exactly the same. CM damage increased across the AWII project during the second generation as measured on-tree during the preharvest sample (Table 2b). Note that in orchards A4 and A6 separate damage assessments were made as the two main varieties in each block matured at different rates. Four of the SOFT blocks and 6 of the CONV blocks had measurable CM damage. Four of the orchards (A3, A4, A5, and A6) were under high pressure and had significant fruit damage. In each of these cases more CM damage was noted in the CONV block with the exception of the Delicious apples in orchard A6. Overall, CM damage levels were low with more injury noted in the CONV orchards.

It was not uncommon to see variable results in the bin samples at harvest as compared to the "on-tree' samples described above. The "on-tree" samples were grid-like samples that were biased toward the borders, where damage tended to accumulate, as a means of isolating areas of concern. Five SOFT blocks and 5 CONV blocks had measurable CM damage noted in the bin samples. Three of the blocks shown to have relatively high CM damage during the "on-tree" sampling (A3, A4, and A6) had corresponding elevated damage in the bin samples. The damage level in the CONV block of orchard A10 was a concern as no damage was detected in any previous samples but had the highest damage rating in the bin samples. Closer inspection of both data sets showed that all damaged apples came from two bins from one area of the orchard that was likely missed in the on-tree grid samples as this block was oddly shaped. The bin sample data generally showed less CM damage than the on-tree samples, but was equally successful in denoting the high-pressure blocks. In these samples average CM damage was very low under both treatment regimes, with slightly more damage noted in the CONV blocks.

Adult CM captures in pheromone-baited traps were an indirect measure of assessing relative CM densities in orchards. Cumulative CM captures of greater than four moths/trap in mating disruption orchards (J.F. Brunner) during the first generation was approaching a level that would require supplemental insecticide treatments to suppress CM damage. Five of the orchards (A1, A3, A4, A5 and A6) had captures above that level in at least one of the blocks, orchard A10 was close to that level (Table 3a). During the second generation the trapping system was less efficient in pheromone treated orchards and the treatment threshold was lowered to an average of 2 moths/trap (J.F. Brunner). Seven of the orchards (A9 and A13 added to the above list) had captures above 2 moths/trap during the second generation (Table 3b). Overall, the average CM adult capture in pheromone-baited traps was low with no difference among treatment regimes. It appeared this trapping system adequately identified orchards that were under elevated CM pressure.

An alternate kairomone attractant (DA Lure) was used to monitor male and female CM activity in the AWII orchards (Tables 3c, 3d). On average, DA lure and pheromone lure captures were pretty well correlated with pheromone captures across the AWII project during both generations. However, a couple notable exceptions did exist. Orchard A3 had elevated pheromone captures, but not at a level that made that orchard stand out as being under extreme pressure. CM captures in the DA Lure baited traps were very high in orchard A3 and not well correlated with captures in pheromone-baited traps. By comparison, orchard A5 had captures in DA lure baited traps equivalent to orchard A3, but captured nearly 8-times as many moths in pheromone-baited traps. During the first generation moth captures in DA Lure baited traps were biased toward males (80% males), but during the second generation the sex ratio was near 50:50.

DA Lure baited traps allowed researchers to assess mating success among captured females. Previous data on mating success from AWII (2001, 2002) showed less mating among captured females during the first generation (35% in 2001, 40% in 2002) than during the second generation (63% in 2001, 77% in 2002). This pattern was repeated in 2003. It should be noted that the second generation of 2003 had the lowest percentage of mated females (50%) of the three-year project. There was no consistent difference in CM densities or mating success noted between the treatment regimes as measured by DA Lure captures.

Leafroller:
To assess the efficacy of the experimental treatment regimes it was important to first understand the level of LR pressure each orchard was experiencing at the onset of the

demonstration project. A wide range of LR densities, as measured by season-long trap captures, were present within the 15 AWII apple sites. In 2001 the range of moth capture per block was from 0-895 (average for SOFT 149, CONV 233) for OBLR and 0-554 (average for SOFT 65, CONV 68) for PLR. In 2003 LR pressure in each block was categorized using moth capture in a standard lure-baited trap as High: >200 moths, Moderate: 100-200 moths, Low: 50-99 moths, and Very low: <50 moths per trap. The ratio of captures in the standard and low-load lure-baited trap in each block was used to determine if a LR population was internal (0 to 5), unclear (5 to 10) or external (>10). In OBLR populations were rated as being "high" in 6 CONV blocks (4 of which had an internal population source) and 3 SOFT blocks (with 2 having an internal population source) while PLR populations were rated as being "high" in 4 CONV and 2 SOFT blocks (with none being rated as having an internal population source).

LR larval densities (PLR and OBLR combined) were very low across the AWII project (Tables 2a, 2b). The only exception was the SOFT block of orchard A8, which had nearly 3% LR infested shoots at the petal fall assessment (Table 2a). Orchard A8 had high LR pressure during 2002 in both blocks. In 2003, Success was used at petal fall in the CONV block and provided control of LR larvae immediately. The insect growth regulator Esteem was used in the SOFT block to control both LR and CM eggs. The time-to-kill for Esteem was long, as mortality was generally not noted until the penultimate molt. Therefore, a reduction in LR densities was not seen until the following generation. LR densities were elevated during the second-generation sample of the SOFT block of orchard A8, but not to levels noted during the first generation (Table 2b). On average, LR densities were greater in the SOFT blocks during the second-generation sample. Measurable LR densities were detected in only four of the SOFT blocks and one of the CONV blocks. The difference between the two treatment regimes was significant, but probably not linked to the philosophy of not using OP insecticides in the SOFT block, but rather the choice of using Success in the CONV blocks and Esteem for LR control in the SOFT blocks. It was apparent that a single Esteem application at petal fall was not sufficient to maintain LR control through the entire season in orchards with moderate to high pressure.

LR damage was measured in 8 SOFT blocks and 8 CONV in the bin samples at harvest (Table 2c). The SOFT blocks in orchards A8 and A11 had the highest damage levels. This correlated well with elevated second-generation densities measured in the larval sample (Table 2b). Several blocks that had no detectable populations as measured by the second-generation samples (Table 2b) had LR-injured fruit at harvest as measured by the bin samples. This has not been uncommon when managing small, clustered LR populations, which can be difficult to detect with a visual sample. This underscored the need for a rigorous LR management program even in orchards with relatively low pressure. On average, damage from LR was fairly low, with little difference noted between treatment regimes.

LR populations were measured indirectly with standard and low-load pheromone lures. Low-load pheromone lures can be a more sensitive measure of in-orchard population levels as higher pheromone loads are capable of attracting LR adults from outside sources

(J.F. Brunner). Therefore, only LR captures from low-load pheromone lures were reported in Tables 3a, 3b. LR captures during the first generation measure the population that survived the dormant and petal fall applications and can predict pressure for the second generation. Orchards A1, A3, A7, A8, A9, A11 and A12 had elevated moth captures relative to the other orchards during the first generation (Table 3a) and orchards A1, A8 and A11 had elevated moth captures during the second generation (Table 3b). Moth captures in low-load pheromone orchards appeared to be a relatively good predictor of injury as detected in the harvest samples (Table 2d). The orchards with the biggest difference in fruit injury between the SOFT and CONV blocks (A8 and A11) also had significantly higher moth captures in the SOFT blocks relative to CONV blocks. There was no consistent difference in trap captures noted between treatment regimes.

***Lacanobia subjuncta*/Cutworms:**
It was difficult to measure LAC populations with foliage samples, as the feeding damage was similar to other noctuids, and resembled that of grasshoppers or other foliage feeders. Therefore Table 2a refers to the LAC foliage feeding assessment as "% shoots with chewing damage". A low level of foliage feeding from chewing insects was noted in most treatment blocks. However, unpublished data (Doerr and Brunner) indicated only when generalized foliage feeding reach levels of >10% infested shoots, especially with no corresponding fruit injury, did an accurate species ID become important (Doerr, unpublished). None of the apple or pear blocks had foliage-feeding levels that would indicate LAC or any other noctuid posed a threat to cause significant fruit injury (Table 2a). Seven of the orchards had fruit damage that resembled cutworm/LAC type injury at the harvest bin samples (Table 2c). No consistent pattern existed between treatment regimes, and on average cutworm-type damage was very low. No single orchard appeared to have fruit injury levels that would raise concern.

Unpublished data (Doerr and Brunner) indicated that LAC captures that peak at greater than 100/week presented an elevated risk level. Only orchards A9, A10 and A11 had captures that reached this level during the first generation (Table 3a). There was no difference among treatment protocols noted in these orchards. These three orchards have each had historically elevated LAC pressure but little fruit damage has ever been noted. During the second generation orchards A4, A7, A8, A9 and A11 reached this level in both the CONV and SOFT blocks (Table 3b). There was no consistent difference in trap captures between treatment regimes, and on average total LAC captures were almost identical among treatments.

White apple leafhopper (WALH): Overwintering WALH densities and relative parasitism rates were monitored during the dormant season. Ten cm. sections were cut from one-yr wood before the commencement of shoot growth. Twenty shoots per block were sampled. Shoots were brought back to the lab, trimmed to 10 cm, and examined for leafhopper eggs using 10X magnification. If eggs were found, they were dissected and examined for the presence of a 'fat body', which represents the developing larvae of the egg parasitoid, *Anagrus epos*. This sample was designed to evaluated relative differences among treatments and not to used to predict summer densities. Overwintering WALH densities were generally low with no difference between treatments noted with either density or parasitism rates (Table 4a).

First and second generation WALH nymphs were sampled by examining ten fully expanded leaves from 20 trees in each block. The number of nymphs present on both the upper and lower surfaces was recorded. Samples targeted the peaks of the first (mid-May) and second (mid-August) generations. WALH densities were very low in all blocks at both sample periods (Table 4b). In fact, only two totals WALH nymphs were found during the first generation sample and none during the second generation. Only orchards A7 and A11 had moderate populations develop during the second generation of 2002. These populations did not correspond to elevated densities in those blocks during 2003.

***Campylomma verbasci*:**
A *C. verbasci* nymph sample was taken during the late bloom-petal fall time period. Twenty samples/block were taken by holding a 45 x 45 cm beating tray covered with black cloth underneath a section of branch with a high density of blossoms. The branch was struck sharply three times to dislodge the nymphs onto the tray surface, where they were counted. This sample was not conducted as a measure to assist consultants with treatment decisions, rather as a means to assess the effectiveness of the *C. verbasci* control programs. Of specific interest was whether there was any increased risk from *C. verbasci* in the SOFT blocks from leaving Lorsban out of the delayed dormant applications. AWII orchards have had very low *C. verbasci* densities throughout the evaluation periods. However, it is clear that *C. verbasci* numbers have not increased in the SOFT blocks after three years with no OP insecticides used (Table 5). It should be noted that orchard A5 had relatively high adult captures in fall of 2002 (100-120 adults/trap in both blocks) suggesting A5 had elevated risk potential in 2003. This did not correspond to damaging *C. verbasci* densities during the petal fall period of 2003.

Bin samples taken at harvest showed very little damage associated with true bug feeding (combination of *C. verbasci* and Lygus) (Table 2c). However, a significant level of damage (1.3%) identified as *C. verbasci* damage was seen in the SOFT block of orchard A12. This is troublesome since limb-tap samples described above gave no indication of the potential for damage from *C. verbasci*.

Western Tentiform Leafminer:
Ten leaves from each of 20 trees were examined for the presence of mines. Cluster leaves were sampled for mines of the 1^{st} generation, and mid-shoot leaves were sampled for the 2^{nd} and 3^{rd} generations. Samples were taken during mid-May, mid-July, and mid-August. WTLM densities of the first generation were very low in all plots (Table 6). Orchard A14 had the highest density noted during the third generation sample of 2002 in both the CONV and SOFT blocks. The moderate density noted in 2002 did not result in an elevated population relative to the other blocks in 2003. WTLM densities remained low through 2003 with no difference noted among treatment regimes.

Tetranychid, eriophyid, and predatory mites:

Ten leaves from each of 20 different trees per block (200-leaf composite sample) were gathered in mid-June (will be collected in mid-July and mid-August) and brought back to the lab. Leaves sampled were distributed among both spur and shoot leaves, as well as from the inner and outer canopy. The mites were brushed from the leaves onto a circular glass plate coated with a thin film of sticky material using a mite-brushing machine. Both eggs and motile stages were counted of tetranychid mite species (European red mite [ERM], Twospotted mites [TSSM], McDaniel spider mite) and predatory mites (*Galandromus occidentalis* and *Zetzellia mali*). Only the motile stages of apple rust mite were counted.

Mite densities were low at each site in the mid-June sample (Table 7a). Of all the blocks samples, only A3 had tetranychid densities greater than 1 per leaf. This corresponded with an elevated late season density in 2002. However, other orchards with elevated counts during late 2002 (A1, A7, A9, A11, and A14) did not have corresponding elevated counts in mid-June 2003. Overall, predatory mite counts were low in all orchards. This is not unexpected given the low tetranychid and apple rust mite densities present. Orchard A7 developed a troubling mite situation as noted at the mid-July sample. The absolute tetranychid density of 17.6 mites/leaf in the CONV block is not extremely high, but coupled with no predatory mites detected can lead to an unstable integrated mite program. The same pest:predator situation did not develop in the SOFT block of orchard A7. An inspection of the spray records from that block indicated two Assail applications were made in the CONV block during the first CM generation versus two Intrepid applications in SOFT block. Assail has been implicated with having the potential to disrupt integrated mite control in previous tests (E.H. Beers, J.E. Dunley and J.F. Brunner). Only orchard A15 had elevated tetranychid mite densities later in the season as measured during the mid-August sample. Both blocks in A15 had pest:predator ratios greater than 10:1, which is the maximum ratio necessary to maintain a stable integrated mite program in Washington state apple orchards (E.H. Beers). At this time spray records from that block were not available, but no difference between the SOFT and CONV blocks was noted in orchard A15 for either tetranychid or predatory mites. On average, mite densities were very low throughout the 2003 season with both treatment regimes.

Apple aphid and natural enemies:
Twenty upright vegetative shoots were sampled from each block. Three samples were taken, with the first taken during mid-June then mid-July and mid-August. The number of aphid-infested leaves on the top 10 leaves/shoot was counted. Aphid natural enemies, if present were also counted on the sampled shoots. The included coccinellids, lacewings, *Deraeocoris*, *C. verbasci* and syrphid flies. Aphid populations were generally low as measured at each of the sample dates (Table 8). Natural enemy populations were correspondingly low.

Secondary pest fruit damage:
Fruit damage assessments from all secondary pests were conducted prior to harvest. This sample included fruit infestation from ERM eggs, TSSM adults, and blemishes from

WALH excretion (tar spots) and aphid honeydew. No damage from secondary pests was noted in any AWII block during 2003 (Table 2d).

2003 PESTICIDE USE AND COST ANALYSIS (Apple)

All AWII apple blocks used CM mating disruption, most at rates close to 200 dispensers/acre, or about half the recommended full rate of the dispensers used. CM mating disruption is included as a single insecticide application based on the rate used (400 dispensers per acre = 1 full application and 200 dispenser per acre = 0.5 of an application), with cost based on the number of dispensers per acre. The data presented here include only insecticides and miticides, not fungicides, plant growth regulators or other non-insecticidal products (Table 10a). For example, carbaryl (Sevin) used for crop load management and Lime Sulfur or Rally used for disease suppression were not included in the data. The main OP insecticides used in the CONV treatment blocks were chlorpyrifos (Lorsban) [7 of 15 blocks] and azinphos-methyl (Guthion) [7 blocks] (Appendix 1b). For the control of lepidopteran pests the SOFT blocks relied upon methoxyfenozide (Intrepid) [9 of 15 blocks] and pyriproxifen (Esteem) [9 blocks]. The use of the more selective "soft" insecticides was not limited just to the SOFT blocks; 2 CONV blocks received methoxyfenozide and 2 CONV blocks received pyriproxifen, generally applied soon after bloom for LR control. Spinosad (Success) was used mostly in the CONV blocks for LR control (8 CONV blocks, one SOFT block). Chloronicotinyl insecticides were used in both treatment blocks but to a greater extent in the CONV blocks: imidacloprid (Provado) in 2 CONV and 1 SOFT blocks, thiamethoxam (Actara) in 1 CONV and one SOFT block, and acetamiprid (Assail) in 6 CONV and 3 SOFT blocks. Miticides were used in three of the CONV blocks but not in any of the SOFT blocks.

The total number of insecticide applications was not significantly different between the CONV and SOFT programs in all project years either represented as total number of applications (Table 10a) or whole-acre use equivalents (Table 10b). The number of insecticides that were applied that controlled both CM and LR were higher in the SOFT blocks in all years and were 0.5 more over the duration of the project (Table 10b). By contrast more of the LR specific insecticides were applied to the CONV program blocks than SOFT blocks. There were no differences in the total number of "other' insecticides applied (mostly aphicides or controls for true bugs) in the CONV and SOFT blocks. Very few miticides were applied but they were used slightly more in the CONV blocks than SOFT blocks.

To compare the relative expense of the CONV and SOFT programs only insecticide data are used. These data do not include Sevin (carbaryl), as its main use was to modify crop load. It no doubt had some impact as an insecticide but it was not thought to be an over-riding influence. In 2001 the cost of the CONV program was $30 higher than the SOFT program though there was no statistical difference between them (Table 10a). In 2002 the average cost of the SOFT program declined by $50 per acre and was lower than the CONV program but again the difference was not statistically significant. In 2003 the cost of both the SOFT and CONV programs increased with no difference between them. The apple spray program was driven primarily by CM pressure, and the actual cost incurred by individual orchards and blocks was generally a reflection of CM densities. Overall, the difference in pesticide costs was minimal as a pheromone-based CONV program that included Lorsban and Success for LRs, and Guthion and/or Assail for CM was comparable in price and efficacy to a pheromone-based SOFT program using Esteem and Intrepid for both LR and CM with supplemental Assail applications for CM.

2003 RESULTS (Pear)

Pear Psylla (PP):

The success of any pear pest management program is judged by its ability to manage PP, specifically protecting fruit from russet caused by sooty mold growing in PP honeydew. Fruit was considered damaged if the cumulative area of psylla-caused russet exceeded the area of a nickel. This is a rule-of-thumb that may lead packing sheds to downgrade fruit quality. These fruit may or may not get packed depending on the severity of the damage. On average, psylla damage was moderate across all AWII orchards (Table 2e). However, on an individual basis, two of the orchards (P2, P6) had very low damage levels, two had moderate damage (P1, P3) and two (P4, P5) had damage levels above what would be considered acceptable (>0.5%). No significant difference among treatment regimes was noted; in each case PP damage in the SOFT and CONV blocks were well correlated.

Overwintering adult psylla densities tend to be larger than the first summer generation as the latter are the survivors of pesticide intensive programs aimed at controlling the overwintering generation. Summer psylla densities tend to grow through the second and third summer generations, but limb-taps become an inefficient sampling technique as fruit become easily dislodged. Overwintering PP densities were low following the prebloom programs from each treatment regime at all pear orchards as measured by limb-tap samples with little or no difference among treatment programs (Table 3a). Psylla densities were uniformly low during the first summer generation as measured by limb-tap sampling with no difference among treatment regimes (Table 3b).

Limb-tap samples are a valuable tool for assessing the relative effect of adulticides treatments or the ability of insecticides to deter adult colonization of pear, especially during the prebloom period. However, it is the honeydew excretions of summer nymphs that ultimately causes fruit damage. Therefore, nymph samples taken during June and July can be the best predictor of PP damage. PP treatment thresholds have been established at 0.3 nymphs/leaf (E.C Burts) and this level was reached in each AWII orchard. The nymph counts reported in Table 3e were both a reflection of the success of the PP control programs and a prediction of fruit injury. PP nymph samples were closely correlated with damage observations discussed above (Tables 2e, 3e). Although PP pressure was moderate to high across the AWII project, no significant difference in PP nymph densities were noted between treatment regimes.

Codling moth: No damage was noted from CM in any of the pear plots after the first larval generation (Table 2a). No damage was detected at the preharvest, on-tree samples in the majority of blocks (Table 2b). On average, damage was low across the AWII project with no significant difference among treatment regimes. However, CM damage was detected in both the SOFT and CONV blocks of P3 as well as the CONV blocks of

P4 and P6. In each case, damage levels were near or above an acceptable level of 0.25%. Damage levels reported in Table 2b were well correlated with damage noted in the bin samples taken at harvest (Table 2e). On average, no difference in damage levels between the SOFT and CONV blocks was observed.

CM adult captures in pheromone-baited traps during the first generation were generally low with the notable exception of orchard P3 (Table 3a). Orchard P4 also had captures that exceeded a treatment threshold of 4 moths/trap. This continued a trend in which P3 had the highest captures in. On average, there did not appear to be any significant difference between treatment regimes. During the second generation, adult CM captures continued to increase in orchards P3 and P4 (Table 3b). The elevated captures in these orchards were in both blocks and did not appear to be associated with treatment regimes, but rather elevated pressure across both blocks. On average, no significant difference was noted between different treatment regimes.

Leafroller:

There were no live LR detected at any of the pear sites during the first or second larval sample (Tables 2a, 2b). However, LR damage was noted in harvest bin samples in orchards P4, P5 and P6 (Table 2e). In fact, the damage observed in the CONV block of orchard P6 was greater than an acceptable 0.25% level. This has not been uncommon when managing small, clustered LR populations, which can be difficult to detect with a visual sample. This underscored the need for a rigorous LR management program even in orchards with relatively low pressure. On average, LR damage in the CONV blocks was higher than the SOFT blocks, primarily due to the observations in orchard P6.

LR populations were measured indirectly with standard and low-load pheromone lures. Low-load pheromone lures can be a more sensitive measure of in-orchard population levels as higher pheromone loads are capable of attracting LR adults from outside sources (J.F. Brunner). Therefore, only LR captures from low-load pheromone lures were reported in Tables 3a, 3b. LR captures during the first generation measure the population that survived the dormant and petal fall applications and can predict pressure for the second generation. Orchards P3 and P6 had elevated first generation captures (Table 3a) and that trend continued into the second generation (Table 3b). On average captures were slightly higher in the CONV blocks, but the difference between treatment regimes was not significant.

Grape mealybug (GMB)/Pear rust mite (PRM):

Sampling techniques are generally inefficient for both grape mealybug and pear rust mite. Therefore the most discriminating measure of their relative densities in the AWII project was GMB nymph infestations of fruit at harvest and PRM feeding on the calyx end of pears both observed at harvest in bin samples. GMB is generally not troublesome in the Yakima area of Washington State and was not detected in Orchards P1, P2 and P3 from that area. All Wenatchee area orchards had some level of GMB infestation at harvest. In orchard P4 a troublesome infestation was observed in the SOFT block, and in P6 elevated infestation was noted in the CONV block. On average, no difference was noted between treatment regimes.

PRM damage was generally very low across the AWII project with a couple of notable exceptions. The SOFT blocks of orchards P1 and P3 each had troublesome levels of damage, 0.76% and 0.68% respectively. The ability to manage pear rust mite infestations can be a limiting step in the full implementation of a soft spray program (IGR based or organically accepted) in Washington state pear orchards.

Pear psylla natural enemies:
Several beneficial arthropods were monitored during the limb-tap samples taken biweekly in the AWII pear project. For reporting purposes, the total number of beneficial arthropods/sample was presented in Table 9. These data indicate that no obvious trend in the absolute number of beneficial insects between treatment regimes can be noted at this time. It may take more years and a better understanding of the disruptive effects of some new insecticides that are generally accepted as selective in their modes of action.

Cost analysis of pear spray programs:
The overall cost of the SOFT treatment regime was higher on average than the CONV, and appeared to be driven by a combination of high CM and high PP pressure in a number of the orchards (Table 10). However, it can be noted that in orchards P4 and P6, the cost of the SOFT treatment regime was substantially less than the CONV and the cost range of the treatment regimes over the entire AWII project was similar. The distinction between the treatment regimes was driven by the use of Guthion, Lorsban and Assail for CM and Actara and Agrimek for PP in the CONV blocks versus Intrepid and Esteem for CM and Dimilin, Surround and azadirachtin for PP in the SOFT blocks. Generally the SOFT insecticides required more applications and thus cost slightly more. See Appendix 2b for insecticides used in each treatment regime.

Table 1. Areawide II growers, acreage & varieties

APPLES		Main	
Orchard	**Region**	**Cultivar**	**Acres**
A1	West Richland	Gala	18
A2	Vantage	Early Fuji	28
A3	Mattawa	Spur Red	30
A4	Wapato	Granny Smith	40
A5	Moxee	Spur Red	40
A6	West Yakima	Spur Red/Jonagold/others	17
A7	Quincy	Gala	16
A8	Quincy	Red Delicious	25
A9	Quincy	Golden Delicious	28
A10	Chelan	Red Delicious	30
A11	Orondo	Fuji	20
A12	Orondo	Golden	20
A13	Brewster	Granny Smith	40
A14	Brewster	Fuji	25
A15	Bridgeport	Granny Smith	25

PEARS		Main	
Orchard	**Region**	**Cultivar**	**Acres**
P1	Moxee	Bosc/Anjou	15
P2	Moxee	Red Anjou	20
P3	Naches	Bartlett	16
P4	Monitor	Bosc	17
P5	Dryden	Anjou	20
P6	Entiat	Anjou	16

Table 2a. Mid-year damage assessments, 2003.

	% shoots w/ live LR		% shoots with chewing damage		% CM damage	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.0	0.0	2.4	4.7	0.0	0.0
A2	0.0	0.0	0.1	0.2	0.0	0.0
A3	0.0	0.0	3.9	3.4	0.0	0.1
A4	0.0	0.0	1.3	0.2	0.1	0.0
A5	0.0	0.0	0.0	0.0	0.3	0.0
A6	0.0	0.0	0.0	0.0	0.0	0.0
A7	0.0	0.0	0.0	0.0	0.0	0.1
A8	2.7	0.0	0.0	0.2	0.0	0.0
A9	0.2	0.0	0.0	0.0	0.0	0.0
A10	0.0	0.0	1.2	1.9	0.0	0.1
A11	0.0	0.0	3.4	2.0	0.0	0.0
A12	0.0	0.0	0.1	0.1	0.0	0.0
A13	0.0	0.1	0.8	0.3	0.0	0.0
A14	0.0	0.0	0.1	0.6	0.0	0.1
A15	0.0	0.0	0.4	0.4	0.0	0.0
Avg (SE)	0.193 (0.180)	0.007 (0.007)	0.913 (0.338)	0.933 (0.371)	0.027 (0.021)	0.027 (0.012)
P1	0.0	0.0	0.0	0.0	0.0	0.0
P2	0.0	0.0	0.0	0.0	0.0	0.0
P3	0.0	0.0	0.0	0.0	0.0	0.0
P4	0.0	0.0	0.0	0.0	0.0	0.0
P5	0.0	0.0	0.0	0.1	0.0	0.0
P6	0.0	0.0	0.5	0.2	0.0	0.0
Avg (SE)	0.000 (0.000)	0.000 (0.000)	0.083 (0.083)	0.050 (0.034)	0.000 (0.000)	0.000 (0.000)

Table 2b. Second-generation leafroller and preharvest codling moth damage samples, 2003.

	% shoots w/ live LR		% CM damage	
Orchard	SOFT	CONV	SOFT	CONV
A1	0.4	0.0	0.0	0.0
A2	0.0	0.0	0.0	0.0
A3	0.0	0.0	0.1	0.2
A4	0.0	0.0		
A4-Gala			0.6	1.9
A4-Granny Smith			0.1	0.1
A5	0.0	0.0	0.0	1.5
A6	0.0	0.0		
A6-Goldens			0.2	1.2
A6-Delicious			0.3	0.2
A7	0.1	0.0	0.0	0.0
A8	0.5	0.0	0.0	0.0
A9	0.0	0.1	0.0	0.0
A10	0.0	0.0	0.0	0.0
A11	0.4	0.0	0.0	0.0
A12	0.0	0.0	0.0	0.1
A13	0.0	0.0	0.0	0.1
A14	0.0	0.0	0.1	0.0
A15	0.0	0.0	0.0	0.0
Avg (SE)	0.093 (0.046)	0.007 (0.007)	0.08 (0.04)	0.31 (0.15)
P1	0.0	0.0	0.0	0.0
P2	0.0	0.0	0.0	0.0
P3	0.0	0.0	0.5	0.2
P4	0.0	0.0	0.0	0.6
P5	0.0	0.0	0.0	0.0
P6	0.0	0.0	0.0	0.2
Avg (SE)	0.00 (0.00)	0.00 (0.00)	0.08 (0.08)	0.17 (0.10)

Table 2c. Apple harvest fruit injury evaluations (bin samples), 2003.

	Percent fruit injury							
	Codling moth		Leafroller		Cutworm-type		Camp+Lygus	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.00	0.04	0.12	0.08	0.04	0.04	0.00	0.00
A2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
A3	0.32	0.04	0.00	0.32	0.00	0.00	0.04	0.00
A4	0.08	0.16	0.00	0.00	0.00	0.00	0.00	0.00
A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A6	0.04	0.12	0.00	0.00	0.00	0.00	0.12	0.08
A7	0.04	0.00	0.08	0.32	0.00	0.12	0.00	0.00
A8	0.00	0.00	0.76	0.16	0.04	0.00	0.00	0.00
A9	0.00	0.00	0.12	0.04	0.16	0.12	0.00	0.16
A10	0.00	0.72	0.00	0.00	0.00	0.00	0.00	0.00
A11	0.00	0.00	0.64	0.08	0.00	0.08	0.00	0.00
A12	0.04	0.00	0.20	0.16	0.08	0.12	1.28	0.40
A13	0.00	0.00	0.04	0.00	0.00	0.00	0.04	0.00
A14	0.00	0.00	0.04	0.04	0.00	0.00	0.00	0.00
A15	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00
Avg (SE)	0.03 (0.02)	0.07 (0.05)	0.13 (0.06)	0.08 (0.03)	0.02 (0.01)	0.03 (0.01)	0.10 (0.08)	0.05 (0.03)
2002	0.07	0.07						
2001	0.05	0.11						

Table 2d. Preharvest damage assessments (apples on tree), 2003.

	% ERM egg infestation		% OW TSSM infestation		% WALH tarspots		% Aphid honeydew	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avg (SE)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)

Table 2e. Pear harvest fruit injury evaluations (bin samples), 2003.

	Percent fruit injury									
	Pear psylla russet		Grape mealy bug nymphs		Codling moth		Leafroller		Pear rust mite	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV
P1	0.20	0.28	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.08
P2	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
P3	0.40	0.24	0.00	0.00	0.32	0.16	0.00	0.00	0.68	0.08
P4	2.52	3.60	12.48	2.52	0.08	0.24	0.04	0.08	0.00	0.00
P5	1.32	0.67	1.48	1.17	0.00	0.00	0.04	0.17	0.00	0.00
P6	0.00	0.00	1.92	9.20	0.04	0.04	0.00	0.48	0.00	0.00
Avg (SE)	0.74 (0.41)	0.82 (0.56)	2.65 (2.00)	2.15 (1.47)	0.07 (0.05)	0.07 (0.04)	0.01 (0.01)	0.12 (0.08)	0.24 (0.15)	0.03 (0.02)
2002	0.36	0.23			0.07	0.17				

Table 3a. Trap captures of adult arthropods during the first generation, 2003.

	Total LR-Low load		LAC		CM-Pheromone	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	7	29	24	49	1.0	6.3
A2	0	1	97	81	0.0	0.8
A3	46	56	109	184	2.3	4.8
A4	4	2	241	370	1.1	5.6
A5	0	0	184	77	14.3	38.0
A6	0	0	156	154	4.8	1.3
A7	9	3	343	87	2.3	0.3
A8	23	7	367	166	1.0	0.0
A9	8	5	249	338	0.4	0.6
A10	0	3	268	406	3.5	1.5
A11	16	3	697	919	1.0	0.3
A12	7	10	307	287	0.5	0.3
A13	1	2	348	247	0.3	1.8
A14	0	0	61	90	0.2	2.4
A15	0	0	91	70	0.0	3.0
Avg (SE)	8.1 (3.2)	8.1 (3.9)	236.1 (43.7)	235.0 (57.6)	2.2 (0.9)	4.5 (2.5)
	Total LR-Low load		PP ad / b. tray*		CM-Pheromone	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
P1	5	0	0.29	0.55	0.0	4.3
P2	1	1	0.26	0.36	0.0	0.5
P3	0	3	0.48	0.42	18.8	24.3
P4	14	9	1.34	2.95	6.0	8.8
P5	0	0	1.9	1.78	1.5	1.3
P6	4	10	1.84	4.05	2.0	1.0
Avg (SE)	4.0 (2.2)	3.8 (1.9)	1.0 (0.3)	1.7 (0.6)	4.7 (3.0)	6.7 (3.7)

General timing: beginning of season-early July.

* Psylla samples averaged from start of season-June (overwintering adults).

Table 3b. Trap captures of adult arthropods during the second generation, 2003.

	Total LR-Low load		LAC		CM-Pheromone	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	91	134	101	67	0.8	4.0
A2	4	1	30	31	0.0	0.0
A3	18	34	245	290	0.7	2.7
A4	6	9	420	588	8.3	9.0
A5	9	3	249	149	6.0	2.9
A6	4	5	244	279	0.5	5.8
A7	10	8	641	191	0.5	0.8
A8	144	55	652	415	0.5	0.3
A9	26	14	414	671	8.0	0.4
A10	7	6	180	156	0.8	1.0
A11	120	41	850	1207	0.0	0.5
A12	8	18	361	280	0.5	0.0
A13	1	4	327	163	3.0	0.3
A14	0	8	262	234	0.6	1.6
A15	0	0	68	104	0.0	0.0
Avg (SE)	29.9 (12.2)	22. 7 (9.0)	336.3 (59.6)	321.7 (78.5)	2.0 (0.8)	1.9 (0.7)
	Total LR-Low load		PP ad / b. tray*		CM-Pheromone	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
P1	8	15	0.07	0.05	0.8	0.3
P2	0	10	0.01	0.01	0.0	1.5
P3	17	41	0.72	0.43	49.3	40.3
P4	13	2	0.15	0.15	14.8	9.8
P5	1	0	0.11	0.16	4.0	2.3
P6	11	15	0.25	0.03	0.8	0.3
Avg (SE)	8.3 (2.8)	13.8 (6.0)	0.2 (0.1)	0.1 (0.1)	11.6 (7.9)	9.1 (6.4)

General timing: Early July-end of season.

* Psylla samples averaged from June-end of July (first generation summerform adults).

Table 3c. Codling moth captures in traps baited with DA-Lure during the first generation, 2003.

	Avg CM/trap		% Males		% Mated females	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.5	1.6	100.0	100.0	---	---
A2	0.5	2.5	44.4	77.8	40.0	50.0
A3	18.5	21.3	73.9	67.2	24.1	26.2
A4	1.6	5.0	76.9	82.5	66.2	71.4
A5	17.9	20.3	81.8	68.5	46.2	47.1
A6	2.3	2.3	44.4	77.8	40.0	50.0
A7	3.0	0.5	50.0	50.0	50.0	100.0
A8	0.4	0.6	50.0	100.0	0.0	---
A9	0.2	0.7	100.0	75.0	---	100.0
A10	0.0	0.3	---	100.0	---	---
A11	0.5	0.0	50.0	---	0.0	---
A12	0.0	0.0	---	---	---	---
A13	0.0	0.0	---	---	---	---
A14	0.2	0.2	100.0	100.0	---	---
A15	0.4	0.0	100.0	---	---	---
Avg (SE)	3.1 (1.6)	3.7 (1.8)	72.6 (6.9)	81.7 (5.1)	33.3 (7.9)	63.5 (10.6)

General timing: beginning of season-early July.

Table 3d. Codling moth captures in traps baited with DA-Lure during the second generation, 2003.

	Avg CM/trap		% Males		% Mated females	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	1.3	3.4	20.0	76.5	75.0	25.0
A2	0.3	0.7	50.0	50.0	100.0	50.0
A3	8.3	11.5	72.0	56.5	14.3	20.0
A4	2.8	6.5	50.0	67.3	72.7	47.1
A5	1.8	4.9	35.7	61.5	44.4	60.0
A6	0.0	0.8	---	66.7	---	100.0
A7	5.8	2.5	52.2	60.0	54.5	25.0
A8	0.0	0.8	---	100.0	---	---
A9	0.2	0.8	100.0	40.0	---	66.7
A10	0.5	0.8	33.3	20.0	0.0	0.0
A11	1.0	0.3	0.0	0.0	50.0	0.0
A12	0.5	0.5	50.0	50.0	---	100.0
A13	0.1	0.1	100.0	0.0	---	100.0
A14	0.2	0.8	0.0	25.0	0.0	100.0
A15	0.6	0.0	0.0	66.7	100.0	0.0
Avg (SE)	1.6 (0.6)	2.3 (0.8)	43.3 (0.9)	49.3 (7.2)	51.1 (11.8)	49.6 (10.5)

General timing: Early July-end of season.

Table 3e. Pear psylla nymph samples, 2003.

	Avg PP nymphs/lf*	
Block	SOFT	CONV
P1	0.52	0.78
P2	0.13	0.02
P3	0.61	0.61
P4	0.54	0.65
P5	0.75	0.59
P6	0.22	0.03
Avg (SE)	0.46 (0.10)	0.45 (0.14)

* PP nymph samples from upper canopy shoots during the second and third summer generations.

Table 4a. Overwintering white apple leafhopper egg samples, 2003.

		Total Eg/20 shoots (10 cm)		% Parasitized	
Block	Date	SOFT	CONV	SOFT	CONV
A1	1-Apr	1	0	100.0	---
A2	1-Apr	0	0	---	---
A3	1-Apr	65	38	40.0	52.6
A4	24-Mar	0	0	---	---
A5	24-Mar	74	21	56.8	38.1
A6	24-Mar	9	18	44.4	61.1
A7	1-Apr	16	24	68.8	58.3
A8	1-Apr	61	9	41.0	44.4
A9	1-Apr	10	158	50.0	52.5
A10	31-Mar	19	42	42.1	45.2
A11	31-Mar	128	226	53.9	41.6
A12	31-Mar	0	0	---	---
A13	31-Mar	5	3	40.0	33.3
A14	31-Mar	10	4	20.0	0.0
A15	31-Mar	3	0	66.7	---
Avg (SE)		26.7 (9.8)	36.2 (17.0)	52.0 (5.5)	42.7 (6.0)

Table 4b. White apple leafhopper nymph samples during the first and second generation, 2003.

	WALH nymps/leaf			
	1st Generation (Late May)		2nd Generation	
Orchard	SOFT	CONV	SOFT	CONV
A1	0.000	0.000	0.000	0.000
A2	0.000	0.000	0.000	0.000
A3	0.000	0.000	0.000	0.000
A4	0.000	0.000	0.000	0.000
A5	0.000	0.000	0.000	0.000
A6	0.000	0.000	0.000	0.000
A7	0.005	0.000	0.000	0.000
A8	0.000	0.000	0.000	0.000
A9	0.000	0.005	0.000	0.000
A10	0.000	0.000	0.000	0.000
A11	0.000	0.000	0.000	0.000
A12	0.000	0.000	0.000	0.000
A13	0.000	0.000	0.000	0.000
A14	0.000	0.000	0.000	0.000
A15	0.000	0.000	0.000	0.000
Avg (SE)	0.0003 (0.0003)	0.0003 (0.0003)	0.000 (0.000)	0.000 (0.000)

Table 5. *Campylomma verbasci* nymph sampling using limb-tap and beating tray technique during the bloom period, 2003.

		Campylomma nymps/tray	
Orchard	Date	SOFT	CONV
A1	4/22	0.00	0.00
A2	4/22	0.00	0.00
A3	4/22	0.00	0.00
A4	4/23	0.05	0.10
A5	4/23	0.20	0.10
A6	4/23	0.00	0.00
A7	4/29	0.00	0.00
A8	4/29	0.00	0.00
A9	4/29	0.00	0.00
A10	5/8	0.00	0.00
A11	5/1	0.10	0.15
A12	5/1	0.00	0.00
A13	5/8	0.00	0.00
A14	5/8	0.00	0.00
A15	5/8	0.00	0.00
Avg (SE)		0.02 (0.002)	0.02 (0.013)

Table 6. Western tentiform leafminer sampling, 2003.

	WTLM mines/leaf					
	Late May		Mid-July		Mid-August	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.000	0.000	0.00	0.00	0.00	0.00
A2	0.000	0.000	0.00	0.01	0.03	0.06
A3	0.000	0.000	0.00	0.02	0.00	0.00
A4	0.000	0.000	0.00	0.00	0.01	0.00
A5	0.000	0.000	0.00	0.00	0.00	0.00
A6	0.000	0.000	0.00	0.00	0.00	0.00
A7	0.005	0.000	0.00	0.00	0.00	0.00
A8	0.000	0.000	0.00	0.00	0.00	0.02
A9	0.000	0.005	0.00	0.00	0.00	0.00
A10	0.000	0.000	0.00	0.00	0.00	0.00
A11	0.000	0.000	0.00	0.00	0.02	0.00
A12	0.000	0.000	0.00	0.00	0.00	0.00
A13	0.000	0.000	0.00	0.00	0.00	0.00
A14	0.005	0.000	0.00	0.00	0.00	0.00
A15	0.005	0.045	0.01	0.00	0.00	0.00
Avg (SE)	0.001 (0.0005)	0.003 (0.003)	0.001 (0.001)	0.001 (0.001)	0.004 (0.002)	0.005 (0.004)

Table 7a. Mite samples using leaf-brushing technique, 2003 (motile mites only reported).

		Tetranychid Mites		Predatory Mites		Apple Rust Mites	
Orchard	Date	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	10-Jun-03	0.04	0.61	0.00	0.00	0.00	0.00
A2	10-Jun-03	0.00	0.00	0.32	0.56	0.00	0.14
A3	10-Jun-03	1.20	4.22	0.04	0.03	0.04	0.01
A4	10-Jun-03	0.00	0.01	0.00	0.00	0.00	0.00
A5	10-Jun-03	0.22	0.59	0.46	0.09	0.00	0.03
A6	10-Jun-03	0.03	0.00	0.01	0.10	0.00	0.01
A7	10-Jun-03	0.04	0.12	0.00	0.01	0.00	0.00
A8	10-Jun-03	0.00	0.00	0.04	0.02	0.00	0.03
A9	10-Jun-03	0.15	0.11	0.01	0.00	0.00	0.00
A10	12-Jun-03	0.03	0.09	0.01	0.00	0.00	0.00
A11	12-Jun-03	0.01	0.00	0.00	0.00	0.00	0.00
A12	11-Jun-03	0.80	0.30	0.00	0.00	0.00	0.00
A13	12-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00
A14	12-Jun-03	0.00	0.00	0.00	0.00	0.00	0.00
A15	12-Jun-03	0.00	0.00	0.00	0.02	0.00	0.00
Avg (SE)		0.17 (0.09)	0.40 (0.28)	0.06 (0.04)	0.06 (0.04)	0.00 (0.00)	0.01 (0.01)

Table 7b. Mite samples using leaf-brushing technique, 2003 (motile mites only reported).

		Tetranychid Mites		Predatory Mites		Apple Rust Mites	
Orchard	Date	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	10-Jul-03	0.32	0.40	0.00	0.00	0.00	0.00
A2	10-Jul-03	0.01	0.00	0.07	0.04	0.00	0.00
A3	10-Jul-03	0.44	0.32	0.60	0.96	8.00	0.00
A4	15-Jul-03	0.04	0.02	0.06	0.02	8.60	4.10
A5	15-Jul-03	0.12	0.34	0.24	0.06	5.00	1.50
A6	15-Jul-03	1.70	0.04	0.18	0.54	32.40	0.32
A7	10-Jul-03	1.42	17.60	0.04	0.00	0.10	0.80
A8	10-Jul-03	0.02	0.00	0.92	0.20	2.50	12.70
A9	10-Jul-03	0.66	0.70	0.96	0.04	8.30	0.50
A10	18-Jul-03	0.75	4.18	0.06	0.14	30.30	34.80
A11	16-Jul-03	0.05	0.86	0.01	0.00	3.80	0.80
A12	16-Jul-03	0.19	0.01	0.00	0.00	0.10	0.60
A13	15-Jul-03	1.12	0.16	0.02	0.00	1.40	1.00
A14	18-Jul-03	0.06	0.50	0.02	0.00	4.40	7.50
A15	18-Jul-03	0.50	0.43	0.06	0.05	20.70	1.80
Avg (SE)		0.49 (0.14)	1.70 (1.17)	0.22 (0.09)	0.14 (0.07)	8.37 (2.78)	4.43 (2.35)

A7: Two Assail applications in CONV vs two Intrepid applications in SOFT.

Table 7c. Mite samples using leaf-brushing technique, 2003 (motile mites only reported).

		Tetranychid Mites		Predatory Mites		Apple Rust Mites	
Orchard	Date	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	11-Aug-03						
A2	13-Aug-03	0.20	0.32	0.02	0.02	0.00	0.00
A3	11-Aug-03	0.02	0.00	0.00	0.05	0.00	0.60
A4	13-Aug-03	0.00	0.00	0.04	0.04	0.00	0.00
A5	13-Aug-03	0.00	0.04	0.04	0.38	0.20	0.90
A6	13-Aug-03	0.24	0.66	0.50	0.36	0.00	0.60
A7	13-Aug-03	0.20	0.02	0.28	0.17	0.00	0.70
A8	13-Aug-03	0.94	0.62	0.06	0.10	0.10	0.00
A9	13-Aug-03	0.02	0.08	0.62	0.74	0.00	0.00
A10	14-Aug-03	0.02	3.18	0.79	0.02	0.00	0.00
A11	14-Aug-03	0.60	0.00	0.20	0.16	0.60	0.80
A12	14-Aug-03	0.13	0.16	0.53	1.20	0.00	0.00
A13	14-Aug-03	0.86	2.36	0.04	0.02	0.00	0.00
A14	14-Aug-03	0.66	1.33	0.00	0.00	8.60	0.00
A15	14-Aug-03	16.00	18.50	0.80	0.50	0.00	0.00
Avg (SE)		1.33 (1.05)	1.82 (1.22)	0.27 (0.08)	0.26 (0.09)	0.65 (0.57)	0.25 (0.09)

Table 8. Aphid and predator complex, 2003.

	June				July			
	% inf shoots		Mot. predators/shoot		% inf shoots		Mot. predators/sho	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV
A1	0.05	0.50	0.00	0.00	1.20	0.60	0.00	0.00
A2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A3	0.05	0.10	0.00	0.00	0.05	0.00	0.00	0.00
A4	0.35	0.35	0.00	0.00	0.00	0.00	0.00	0.00
A5	0.00	0.00	0.00	0.05	0.05	0.15	0.00	0.00
A6	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A7	0.00	0.00	0.00	0.00	1.50	0.00	0.00	0.00
A8	0.05	0.25	0.00	0.00	0.00	0.00	0.00	0.00
A9	0.10	0.00	0.00	0.00	0.80	0.35	0.00	0.00
A10	0.00	0.05	0.00	0.00	0.00	0.00	0.00	0.00
A11	0.00	0.00	0.00	0.00	0.00	1.30	0.00	0.00
A12	0.15	0.35	0.00	0.00	0.00	0.00	0.00	0.00
A13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Avg (SE)	0.06 (0.02)	0.11 (0.04)	0.00 (0.00)	0.00 (0.00)	0.24 (0.13)	0.16 (0.09)	0.00 (0.00)	0.00 (0.00)

Table 8 (cont). Aphid and predator complex, 2003.

	August			
	% inf shoots		Mot. predators/shoot	
Orchard	SOFT	CONV	SOFT	CONV
A1	0.00	0.10	0.00	0.00
A2	0.00	0.00	0.00	0.00
A3	0.00	0.00	0.00	0.00
A4	0.00	0.00	0.00	0.00
A5	0.00	0.00	0.00	0.00
A6	0.00	0.00	0.00	0.00
A7	0.35	0.00	0.00	0.00
A8	0.10	0.00	0.00	0.00
A9	0.00	0.00	0.00	0.00
A10	0.00	0.00	0.00	0.00
A11	0.00	1.60	0.00	0.00
A12	0.10	0.00	0.00	0.00
A13	0.50	1.30	0.00	0.00
A14	0.15	0.00	0.00	0.00
A15	0.00	0.00	0.00	0.00
Avg (SE)	0.08 (0.04)	0.20 (0.13)	0.00 (0.00)	0.00 (0.00)

Table 9. Total beneficial arthropods/limb-tap sample,2003.

	Total beneficials/sample	
Orchard	SOFT	CONV
P1	2.5	1.0
P2	0.5	0.8
P3	0.4	0.8
P4	0.5	0.4
P5	0.5	0.8
P6	0.7	0.9
Avg (SE)	0.9 (0.3)	0.8 (0.1)

Table 10a. Cost analysis of insecticide applications, 2003.

	SOFT		CONV	
	# of apps	Total cost	# of apps	Total cost
A1	6	$127.66	9	$200.16
A2	2	$95.68	2	$95.68
A3	13	$249.41	18	$228.92
A4	4	$172.48	4	$232.96
A5	6	$230.40	6	$157.26
A6	8	$214.78	9	$191.06
A7	6	$173.28	10	$247.59
A8	5	$136.17	3	$96.49
A9	6	$152.59	9	$251.52
A10	4	$138.15	3	$101.63
A11	3	$168.96	6	$108.68
A12	6	$214.50	7	$226.62
A13	3	$132.80	4	$110.77
A14	6	178.92	6	132.72
A15	3	$147.20	6	$240.13
Avg (Range)	5.4 (2-13)	$170 ± 11.8 (95.68-249.41)	6.8 (2-18)	$175 ± 16.0 (95.68-251.52)
2002		$138 ± 14.1		$150 ± 12.5
2001		$183 ± 23.7		$151 ± 14.4
P1	15	$347.95	11	$249.76
P2	14	$520.83	11	$290.85
P3	15	$226.74	13	$188.65
P4	18	$525.39	18	$570.42
P5	16	$460.78	16	$460.78
P6	13	$328.35	11	$371.63
Avg (Range)	15.2 (13-18)	$401.67 (226.74-525.39)	13.3 (11-18)	$355.35 (188.65-570.42)
2002		$355.00		$335.00

# of apps: Number of times an insecticide (includes oil and CM pheromone dispensers) was applied to a block.

Table 10b. Average number of foliar insecticides applied per acre equivalent to AWII apple orchards, 2001-2003.

	CM+LR		Leafroller		Mites		Other		Total	
Year	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT
2001	1.9	2.4	1.3	0.6	0.1	0.1	1.8	2.4	5.0	5.5
2002	1.7	2.0	1.2	0.2	0.0	0.0	2.1	2.1	5.1	4.3
2003	2.2	2.7	1.1	0.1	0.2	0.0	2.1	1.6	5.6	4.3
3-year ave.	1.9	2.4	1.2	0.3	0.1	0.0	2.0	2.0	5.2	4.7

Appendix 1. Recommended pesticide options for CONV and SOFT treatments in apple, 2003.

Time of control	Pests targeted for control	Traditional Program (includes OPs if needed)	Selective Program (NO-OP insecticides)
Dormant	Scale, aphids, spider mites	Oil	Oil
	Cutworms	Lorsban, Thiodan	Avaunt, Intrepid
Delayed-dormant	Leafrollers, scale, aphids, spider mites	Oil+Lorsban	Oil[1]
Pre-bloom	Aphids, lygus	Dimethoate	Low rate Provado (RAA)
	Leafminer	Vydate, Oil	Oil
Bloom	Thrips, *Campylomma*	Carzol	Carzol
	Leafroller	Success	Bt, Intrepid
	Codling moth	Pheromone	Pheromone
Petal fall	Leafroller	Success	Intrepid, Esteem, Bt
	Codling moth	NONE	Esteem, Oil
	Scale	Assail	Esteem
	Leafhopper	Sevin, Provado	Oil, Avaunt
Petal fall + 14 days	Leafroller	Success	Esteem, Bt, Intrepid
	Codling moth	NONE	Esteem, Oil
	Leafhopper	Sevin, Provado	Avaunt
Early summer	Codling moth	Guthion, Imidan, Assail	Virus, Intrepid, oil
	Leafroller		LR Pheromone
mid-late summer	Codling moth	Guthion, Imidan, Assail	Intrepid, virus, Oil
	Leafroller	Success	Bt, Intrepid
	Lacanobia fruitworm	Thiodan	Avaunt
	Aphids	Provado	Biocontrol, soap, oil
	Leafminer	Provado, Vydate	Biocontrol, oil, Intrepid
	Mites	AgriMek, Pyramite	Biocontrol, Oil, Savey, Apollo
Pre-harvest	Codling moth	Imidan, Sevin	Intrepid
	Stink bugs	Carzol, Thiodan, Danitol	Carzol, Thiodan
	Leafhoppers	Provado, Sevin	Provado
	Aphids	Provado	Soap
Post-harvest	Woolly Apple Aphid	Diazinon, Thiodan	Thiodan

[1] Use oil here if not used earlier because of availability of water.

Appendix 1b. Number of insecticide applications per treatment regimes in apple, 2003.

	Avg applications/acre				Total Applications/acre	
	SOFT	CONV		Total by class	SOFT	CONV
Guthion	0.0	0.6		Organophosphates	0.0	1.4
Lorsban	0.0	0.5				
Diazinon	0.0	0.1				
Dimethoate	0.0	0.1				
Imidan	0.0	0.1				
Assail	0.2	0.6		Chloronicotinyls	0.4	0.8
Provado	0.1	0.1				
Actara	0.1	0.1				
Intrepid	1.3	0.3		Growth regulators	2.0	0.4
Esteem	0.7	0.1				
Vendex	0.0	0.1		Miticides	0.0	0.2
Apollo	0.0	0.1				
Success	0.1	0.5				
Bt	0.0	0.1				
Pheromone	0.5	0.5				
Sevin	0.6	0.7				
Carzol	0.2	0.2				
Oil	1.3	1.6				

Appendix 2a. Recommended pesticide options for CONV and SOFT treatments in pear, 2003.

Standard

Dormant	Delayed Dormant	Clusterbud	Petalfall	Post Petalfall	Summer
Oil	Oil	Actara	Agri-Mek	Agri-Mek	Agri-Mek
Surround	Surround	Assail	Actara	Actara	Actara
	Sulfurs	Pyramite	Provado	Provado	Provado
	Thiodan	Surround	Assail	Assail	Assail
		Oil	Pyramite	Pyramite	Pyramite
			MD	MD	MD
				Ops	Ops
				Savey / Apollo	Vendex
					Savey / Apol
No pyrethroids all year					

IGR

Dormant	Delayed Dormant	Clusterbud	Petalfall	Post Petalfall	Summer
Oil	Oil	Esteem	Esteem	Esteem	Esteem
Surround	Surround	Dimilin	Dimilin	Dimilin	Dimilin
	Sulfurs	Oil	Neemix / Aza-Direct	Neemix / Aza-Direct	Neemix / Aza Direct
	Thiodan	Surround	MD	MD	MD
		Neemix / Aza-Direct	Acramite	Intrepid	Intrepid
				Apollo/Savey	Apollo/Save
				Acramite	Acramite
		No pyrethroids, chloronicotinyls or OPs			

Appendix 2b. Number of insecticide applications per treatment regimes in pear, 2003.

	Avg applications/acre				Total Applications/acre	
	SOFT	CONV		Total by class	SOFT	CONV
Guthion	0.0	0.8		Organophosphate	0.0	1.0
Lorsban	0.0	0.2				
Assail	0.0	0.3		Chloronicotinyls	0.0	0.8
Actara	0.0	0.5				
Provado	0.0	0.0				
Thiodan	0.2	0.2				
Agrimek	0.0	0.7				
Pheromone	0.3	0.3				
Dimilin	0.2	0.0		Growth regulators	4.7	2.0
Intrepid	0.8	0.0				
Esteem	2.0	1.0				
Azadirachtin	1.7	1.0				
Surround	2.3	1.3				
Acramite	0.3	0.7		Miticides	0.8	1.3
Pyramite	0.0	0.3				
Vendex	0.2	0.0				
Apollo	0.0	0.2				
Carzol	0.3	0.2				
Sulfur	0.2	0.0				
Oil	5.2	5.3				