Project title: IGR All the Time: the third year of AWII in pear

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Justification:

There are several economically important arthropod pests of pear, with codling moth and pear psylla as the most important. Codling moth has been the subject of numerous research projects to replace organophosphate insecticides, particularly on an areawide basis (e.g., CAMP). These projects have been successful in demonstrating that an areawide approach works best for reducing this key pest. Pear psylla has also been the subject of many research projects aimed at replacing chemical control tactics, although these projects have not addressed areawide management of this pest.

Recent projects have looked at extending the benefits of removing organophosphates from orchard pest management. One such project has been funded by the Apple Entomology grants program of the Washington Tree Fruit Research Commission, *New pest management programs for apple and pear*, with Jay Brunner as lead principal investigator. This project was co-funded by a multi-year Areawide II RAMP/IFAFS USDA grant and looked at the ramifications of removing organophosphates for codling moth control in apple and pear. While this change could prove challenging in apple, it was much more feasible in pear where the fruit is less susceptible to damage. As such, when the project was initiated with cooperators in Oregon and California in 2001 it was decided that the pear portion would also remove abamectin (Agri-Mek). It was hoped that reducing the use of Agri-Mek would increase the potential for biocontrol. However, other disruptive broad-spectrum insecticides replaced Agri-Mek, such as the chloronicotinyls thiamethoxam (Actara) and imidacloprid (Provado). In that year, codling moth was easily managed by mating disruption while pear psylla control was easily maintained by the chloronicotinyls. However, any potential increase in biocontrol by using mating disruption was negated by the chloronicotinyl use.

The project moved closer to pushing the limits of IPM in 2002. The non-OP treatment was further limited to only selective materials. Much like organic production is arbitrarily limited to botanical or naturally derived insecticides, it was decided that the selective program would be limited to soft materials, primarily those with growth regulator activity. This would provide pest management along with an environment with limited disruption to natural enemies.

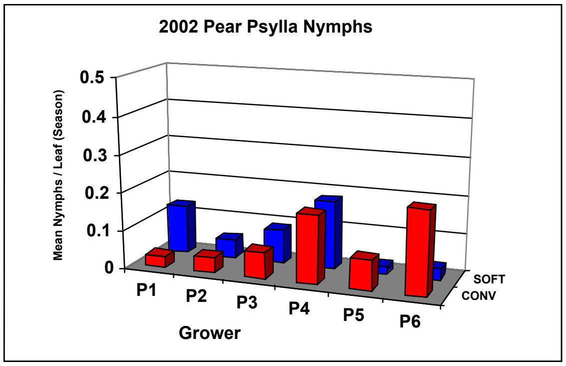
Results from the first two years are presented below (also see Methods for a description of sites and sampling protocols). The project has been successful over those two years but needs a third year of study to reach meaningful conclusions. Inter-year variation in pest density could lead to incorrect conclusions if the results are based on only two years; a third season reduces that likelihood. More importantly, having a third year of study will allow natural enemies yet another season to establish in the soft programs. The results so far have not shown an appreciable increase in natural enemies. Whereas increasing biocontrol is a goal of most IPM programs, it has rarely been documented in commercial agriculture; this program at least provides the opportunity for it to occur.

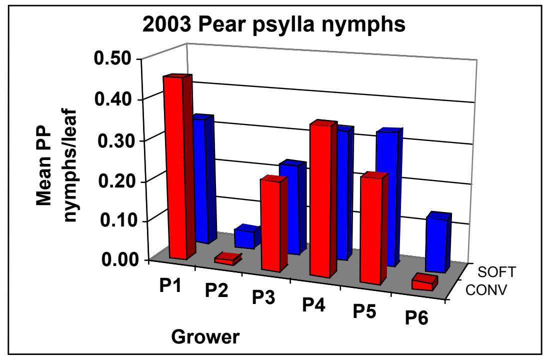
However, including the third year of study does not remove the possibility that the program is appropriate only for the locations in which it was implemented, even though the locations are geographically distributed. Instead, the ultimate test of the feasibility will be the continued increase in implementation of soft pest management programs throughout the pear industry.

Results from 2003-2003

Although pear psylla pressure, as indicated by nymph densities, was moderate to high across the AWII project, no significant differences were found between treatment regimes. In 2003, the average fruit damage from pear psylla was moderate across all AWII orchards. However, 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 differences were found between management programs within each of the orchards. Pear psylla damage in the SOFT and CONV blocks were well correlated with pear psylla densities.

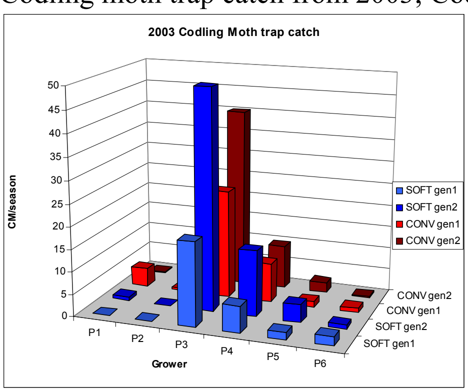
Densities of pear psylla nymphs, 2002 and 2003.

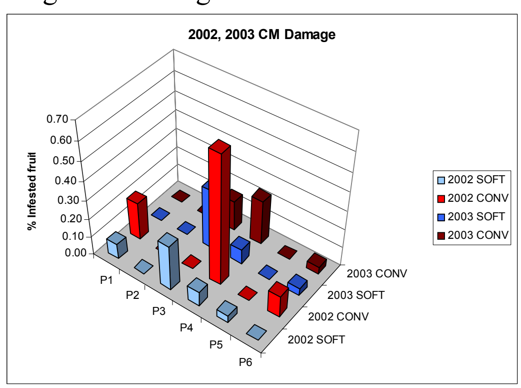




For codling moth, adult captures in pheromone-baited traps during the first generation were generally low, with the notable exception of orchard P3. During the second generation, adult codling moth captures continued to increase in orchards P3 and P4. The elevated trap catches in these orchards were in both SOFT and CONV blocks and were not associated with treatment regimes.

Codling moth trap catch from 2003; Codling moth damage from 2003-2003.



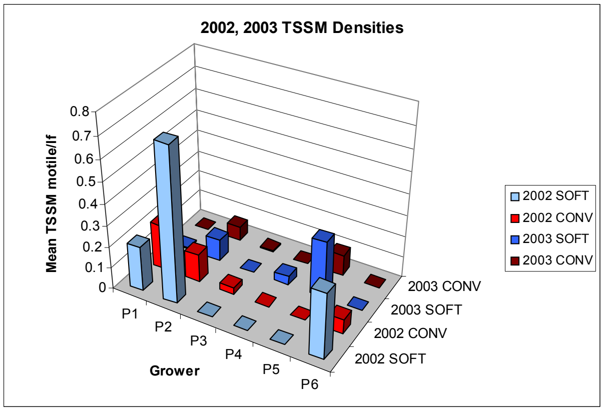


There were no live leafrollers detected at any of the pear sites during the first or second larval sample in 2003. However, leafroller damage was noted in harvest bin samples in orchards P4, P5 and P6 (Wenatchee area blocks). The damage observed in the CONV block of orchard P6 was at 0.25%. Leafroller populations were measured indirectly with standard and low-load pheromone lures. On average, captures were slightly higher in the CONV blocks, but the differences in density and control between treatment regimes were not significant.

Spider mites did not reach damaging levels in either program in 2003. This was not unexpected, as both SOFT and CONV programs have the same effective material available for spider mite control.

Bifenazate (Acramite) has growth regulator activity and has become a widely used acaricide in conventional pear production.

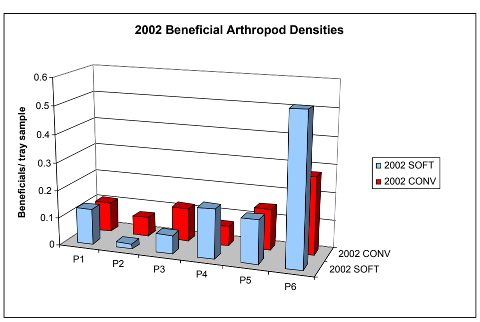
Twospotted spider mite densities, 2002-2003.

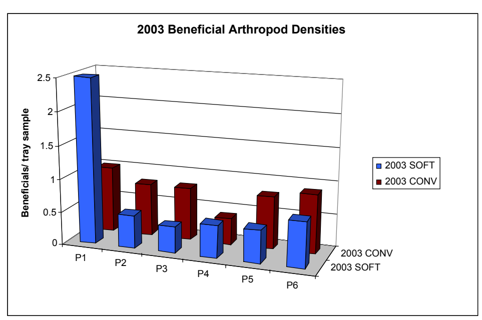


Sampling for grape mealybug and pear rust mite was difficult, and monitoring efforts did not provide a clear measure of the risk a block had for damage. Grape mealybug was generally not troublesome in the Yakima orchards. All Wenatchee area orchards had some level of grape mealybug infestation at harvest. 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 differences were noted between treatment regimes, although treatment options for grape mealybug do not currently include any insect growth regulators (in the case of high infestation, chloronicotinyls would be resorted to). Pear rust mite damage was generally very low across the AWII project with a couple of exceptions. The SOFT blocks of orchards P1 and P3 each had elevated 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 (both IGR-based and certified organic) in Washington State pear orchards.

Several beneficial arthropods were monitored with the limb-tap samples taken biweekly in the AWII pear project. Results indicated no obvious trend in the absolute number of beneficial insects between treatment regimes (CONV seasonal mean = 0.8 beneficials / beat tray, SOFT = 0.9). It may take more time and a better understanding of the disruptive effects of some new insecticides to manage pear orchards to take greater advantage of arthropod natural enemies.

Natural enemy densities, 2002-2003.





All treatment-blocks had 2500 pears examined during harvest for pest damage (Table 1). Russet caused by pear psylla was detected in 10 of 12 treatment-blocks, but in only one block (P3 SOFT) did marked fruit exceed 0.4%. In the NCW orchards (P4-P6), marking from pear psylla honeydew was consistently lower in the SOFT blocks, in line with the lower psylla adult and nymph densities found there. Fruit was considered marked if the cumulative area of psylla-caused russet exceeded the area of a nickel. Grape mealybug counts reflect fruit infested with nymphs, and these infestations were only found in NCW. Fruit infestation by grape mealybug was of particular concern in orchard P4, especially in the SOFT treatment block. Codling moth damage was low; the damaged fruit was found mostly on block edges. Leafroller damage was quite low, if present at all. Pear rust mite damage was noted on the fruit in two orchards (P1 and P3) and was particularly prevalent in the SOFT block of P3; additional controls will be needed in 2003 to reduce this potentially serious pest. Other pest damage was found at low and variable amounts and appeared unrelated to the treatment program.

Table 1. Fruit evaluations at harvest, AWII pear orchards, 2002-2003.

	Percent fruit injury									
	Pear psylla russet		Grape mealybug nymphs		Codling moth		Leafroller		Pear rust mite	
Orchard	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV	SOFT	CONV
2002	0.36	0.23	6.02	3.63	0.07	0.17	0.05	0.07	1.54	0.07
2003	0.74	0.82	2.65	2.15	0.07	0.07	0.01	0.12	0.24	0.03

The overall cost of the SOFT treatment regime was higher on average than the CONV in the second year (Table 2). The differences were driven by a combination of high codling moth and high pear psylla pressure in a number of the orchards. However, 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 largely due to the use of Guthion, Lorsban and Assail for codling moth, and Actara and Agri-Mek for pear psylla in the CONV blocks versus Intrepid and Esteem for codling moth, and Dimilin, Surround and azadirachtin for pear psylla in the SOFT blocks. Generally, the SOFT insecticides required more applications and thus cost slightly more.

Table 2. The average number of insecticides (2003) and cost of the different treatment regimes in 2002 and 2003.

	SOFT		CONV	
Year	# of apps	Total cost	# of apps	Total cost
2002 (Range)	15.5 (12-20)	$355.00 (183-491)	14.1 (10-19)	$335.00 (182-579)
2003 (Range)	15.2 (13-18)	$401.67 (226.74-525.39)	13.3 (11-18)	$355.35 (188.65-570.42)

Objectives:

1. Determine the feasibility of implementing a pear pest management program limited to materials selective for biological control, such as insect growth regulators (IGRs).
2. Determine the potential of a selective program for increasing natural enemies and biological control in pear.
3. Compare the costs of a selective pear pest management program with conventional management.

Methods:

As part of the Areawide II project to develop new pest management strategies, six sites were established in 2002 in pear orchards in Washington. Three orchards were located in the Yakima Valley (P1-P3), and three were located in the Wenatchee Valley (P4-P6). Orchards were 15 to 20 acres in size. Each orchard was divided in two, with one half treated as conventional (CONV) and one half treated as selective (SOFT). Any insecticide program could be used in the CONV, including organophosphates, whereas the SOFT treatments were limited to insecticides that are favorable to biological control, primarily the insect growth regulators, and disruptive materials are avoided. These materials include the organophosphates, pyrethroids, chloronicotinyls, abamectin, and pyridaben. Kaolin (Surround) was also included in the SOFT program, as well as in one conventional block.

Each orchard was monitored with pheromone traps for codling moth at a density of one trap per 2.5 acres. Leafrollers and lacanobia fruitworm were monitored with low-load pheromone lures and with one trap for each species in each treatment-block. All traps were checked weekly and the number of moths recorded. Every two weeks, each treatment-block in each pear orchard was monitored separately for pear pests and natural enemies by taking a 20 beat-tray sample. Leaf samples were collected at two-week intervals from each treatment-block from fruiting spurs (mid-May through August) and top shoots (mid-June through August). Pear psylla, pear rust mite and spider mite densities were determined from leaf samples that were brushed and counted at the WSU-TFREC. Field assessments of CM damage were conducted in all treatments in each pear orchard, and the consultants conducted harvest time examinations of fruit in each orchard (2500 fruits/treatment-block).

Orchards at each site were monitored using beating trays to compare effects of different programs on the kinds and abundance of natural enemies. Pest/natural enemy systems to be monitored were spider mites/predatory mites, aphids/parasitoids-predators and leafminer/parasitoids.

The relative efficacies of the CONV and SOFT program were determined by comparing the pest densities based on monitoring activities, densities of natural enemies and the amount of crop injury. Additionally, the number of pesticides used, frequency of applications and costs were compared between programs. All of the above methods will be continued in 2004 to complete this project.

Educational events have been held in each region where the demonstration study sites were located. These are opportunities to provide a local value to the experiences of growers and crop consultants participating in the project. Additionally, the data collected from monitoring activities have been made available on a weekly basis through e-mail; in 2004, we will dedicate a website to presenting data summarized weekly. Educational efforts will be continued through the winter of 2004-05 as a way to extend results to the grower community and influence changes in practices.

Proposed schedule of accomplishments:

The duration of the project is one year and will continue as it has for the past two years. Sampling will begin during the delayed dormant period and continue through harvest. During the sampling season, data will be posted on the web, as well as e-mailed to cooperators. Following harvest, pesticide application records will be collected, and data will be analyzed and summarized. Results of the three-year project will be presented and discussed at tree fruit industry meetings through the winter.

Literature review:

Present pest control programs for pears are largely based on chemical sprays that destroy beneficial as well as pest arthropods within the orchard agroecosystem. At best, these programs have offered temporary protection while producing many unwanted side effects. Control programs based solely on chemical tactics are less desirable because of real or potential human hazards (both at the time of application and as food residues), environmental contamination and increased production costs borne by producers and consumers. Chemical control programs also require high inputs of fossil fuel-derived materials and other non-sustainable supplies. For these reasons, it is necessary to examine alternatives to existing pear pest management programs. Non-chemical pest control, such as biological, semiochemical (pheromones), autocidal or cultural tactics, presents the best alternative to the traditional chemically intensive programs. Biological control is the optimal sustainable approach.

However, biological control alone cannot currently control any of the major arthropod pests of pear (Beers et al. 1993, Horton and Lewis 2001). Thus, to obtain a long-term stable pest management program in pears, research is necessary to develop a consistently effective integrated program that coordinates chemical control with biological control and also uses semiochemical (pheromones) and cultural control practices. Prior to the development of codling moth mating disruption, control of codling moth without organophosphate insecticides was very difficult and costly and served as a major barrier to development of more environmentally benign IPM programs (Gut and Brunner 1998).

Codling moth areawide management projects (CAMP) using mating disruption were established in 1995 with sites in Washington, Oregon and California. The primary objective of the CAMP projects was to reduce organophosphate applications using mating disruption (Brunner et al. 2001). These projects ran through 1999, during which the use of mating disruption for codling moth control in Washington apple orchards increased from less than 5% of the acreage to a peak of about 55% of the acreage in 2000. Overall, the CAMP projects have been viewed as highly successful in promoting and improving IPM programs in apple and pear throughout the US (Brunner et al. 2001).

Another project, "Areawide II," was initiated in 2001. It involves the same cooperators as CAMP and is funded by the USDA IFAFS and RAMP programs. The objective of this project is to extend the benefits of mating disruption, primarily by developing softer IPM programs that enhance biological control in tree fruit. This program is in progress, seeking to further reduce use of organophosphates and develop programs that encourage the use of natural enemies. In addition to codling moth, target pests include pear psylla and leafrollers.

The effects of insecticides on natural enemies have been reviewed in many places (e.g., Croft 1990). In most cases, organophosphates, pyrethroids and other broad-spectrum insecticides are detrimental to arthropod natural enemies. Alternatively, the insect growth regulators are generally safer for beneficial insects (Croft 1990, Brunner et al. 2001). The newer insecticide classes are more variable in their effects on natural enemies. For example, the chloronicotinyls (Assail, Calypso, Actara, etc.) and METIs (Pyramite, Fujimite), which are both fairly broad-spectrum, are detrimental to many biocontrol agents. Spinosad, on the other hand, is selective to some natural enemies, although it is also fairly broad spectrum (Brunner et al. 2001). In general, the insect growth regulators are among the least disruptive insecticides and tend to have the narrowest target pest ranges.

Several studies have attempted to document the direct effects of natural enemies on pear psylla and to establish the potential for biological control. Predatory bugs are the most important biocontrol agents in pear orchards, although documentation of their direct effects has been limited (Westigard et al. 1968, 1979, Horton and Lewis 2000, Horton et al. 1998, 2001, Fye 1985, Fields and Beirne 1973). These studies all describe the densities of natural enemies and their co-occurrence with pear psylla but do not describe the levels of predation. However, Horton and Lewis (2000) do determine the nature of the migration of the natural enemies, coming from surrounding woodland into pear orchards.

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