Washington is the top US producer of fresh market apples, winter pears and sweet cherries representing an annual farm gate value of over one billion dollars. Apples are grown on 172,000 acres, pears on 23,000 acres and cherries on 25,000 acres. The economies of several eastern Washington communities and thousands of jobs result directly from growing, harvesting, packing, marketing and exporting fruit, with many more jobs being created in service and support industries.

Pesticide-based crop protection programs as they have existed for 30-plus years are being challenged on a number of fronts. Resistance has already made many insecticides ineffective against several pests and recently even codling moth, the key pest in western pome fruit orchards, has developed resistance to organophosphate insecticides that have provided control for 30 years. In addition, cross-resistance of codling moth to other classes of insecticides, including insect growth regulators, suggests a potentially disastrous scenario for apple and pear production in the west. Some experts predict that the newly passed Food Quality Act of 1996 will eventually eliminate broad-spectrum insecticide use in much of agriculture. Nearly 80% of the broad-spectrum insecticides applied to pome fruits are directed at the control of codling moth and leafrollers. Research programs are developing and implementing new insect control technologies that will provide alternatives to these broad-spectrum insecticide-based pest management programs. Use of mating disruption to control the codling moth provides a foundation on which to build a pheromone-based pest management program for apple and pear production in Washington. This system has already been adopted on approximately 22,000 acres in Washington with projections of continued growth into the foreseeable future. Establishment of a pheromone-based pest management program opens a window of opportunity for greater use of biological control in orchards. As growers and crop consultants see the long-term advantage of a pheromone-based pest management program in tree fruits, they become more interested in using “soft” chemical controls for other orchard pests so that the full expression of biological control can be realized.

A major challenge of a pheromone-based pest management program is that management decisions on a local scale take on greater importance. Use of action thresholds to determine when and if a control tactic is required and knowledge of which options best fit the situation is the foundation of a pheromone-based pest management program. Therefore, monitoring for pests and their natural enemies to determine their relative abundance has much greater value. Crop consultants working with fruit growers in Washington have been through an educational system and gained practical experience in a pesticide-based pest management paradigm; thus, in order to implement a pheromone-based pest management program they need to be exposed to a new knowledge base and develop new skills.

The Washington tree fruit industry is blessed with an abundance of crop consultants and a structure of
consultant-mediated information dissemination that is unequaled anywhere else in the world. There are an estimated 400 crop consultants serving fruit grower needs in Washington. Consultants are employed by agri-chemical distributors, cooperative or private fruit-packing warehouses, or are private business people offering services for a fee. All consultant services are paid directly or indirectly by the grower. Most consultants are college educated with majors primarily in horticulture, although a few have degrees in entomology or plant pathology. The future of crop consulting in the fruit industry will shift more and more to a fee-based service system; i.e., growers will be charged directly for the type of consulting service they choose to have. Only time and creativity will tell how this will be implemented in different segments of the fruit industry.

The critical fact is that many crop consultants currently do not have the skills or knowledge base to implement a pheromone-based or biologically intensive pest management system. The advanced training program for crop consultants and growers addresses this need. Through an intensive educational program, place-bound consultants and growers can develop the skills and knowledge necessary to successfully implement the more intensive pest management systems of the future.

Courses to be offered and proposed content

The vision of the Advanced Tree Fruit IPM Training Program is to offer a series of intensive workshops (courses) that will directly address the needs of place-bound crop consultants and growers for implementing pheromone-based pest management programs in Washington’s tree fruit industry. Three workshops (courses) are planned that will follow in a required sequence, the concept being that one will provide a set of knowledge to be used in the next. Each workshop will be coupled with a set of in-season field laboratories. The titles of the workshops are given below with detailed outlines of content on the following pages.

Workshop I: Fundamentals of Orchard Ecology
Workshop II: Population Dynamics, Sampling and Thresholds
Workshop III: Biological Control and Biorational Products

Structure of workshops (courses)

Each workshop will be offered in a one-week, eight-hours per day, format. The daily format is envisioned as teaching, practice, testing and review. The first day will begin with orientation and teaching (lecture), followed by practical exercises (laboratories or problem solving), and then testing. The next day will begin with review of material tested on the day before and then follow with the next set of material with teaching, practice and testing. This pattern will be repeated for four days. The final day will be used as a summary and conclusions time, study time for final exam, and then the final testing period. The tests will be scored, with a passing grade of “C” required to attend the in-season field classes.

The in-season field classes will be designed to review materials covered in each workshop and to provide a “hands-on” experience for the students. Three to four of these classes will be offered in association with each workshop and scheduled in advance at times of the season when pests and natural enemies are present and when principles and skills covered in the workshop can be demonstrated.

Student load and educational materials

Each workshop will be limited to 20-25 students. Teaching will be intensive and geared toward activities and discussion that would be restricted if too many students were allowed into one workshop. Participation in the workshops will be on a first-come first-served basis.

Materials used in the workshops will be developed from resources available to the teachers, initially relying heavily upon Orchard Pest Management but eventually publishing a textbook that will be used in future workshops and potentially could be sold as a resource to other states or countries. The need for refresher
courses or retraining after a period of time is an issue that will be addressed at a later date.

**Teaching staff**
The first workshop will be taught primarily by WSU faculty and staff (Dr. Jay Brunner, Dr. Larry Gut, Dr. Betsy Beers, Dr. John Dunley and Dr. Richard Zack). The second and third workshops will be organized and partially taught by WSU faculty, but experts in the different areas, e.g., biological control, will be imported to teach a day or portion of a day. Potential instructors for the second two workshops include Dr. Vince Jones (University of Hawaii), Dr. Tom Unruh (USDA-ARS, Yakima), Dr. Larry Hull (Pennsylvania State University), Dr. John Trumble (University of California at Riverside), and others.

**Recognition**
An Advanced Tree Fruit IPM Training Certificate offered by WSU upon successful completion of the workshop series is a key part of the proposed workshop series. The person paying for the educational experience should be rewarded, and an Advanced Tree Fruit IPM Training Certificate could be used to advance a person’s career. Washington State University has the personnel and leadership to develop and implement this kind of educational program.

**Costs and time-line**
The workshops will cost between $500 and $800 each and will consist of 40 hours of classroom instruction plus four half-day field laboratories (24 hours of instruction).

The first workshop, Fundamentals of Orchard Ecology, is tentatively planned for the winter of 1997-98 to be held at the WSU-TFREC in Wenatchee. Other offerings would be made on a schedule roughly as shown, to be modified based upon need. It would be possible for a person to take all three workshops in one year to obtain an Advanced Tree Fruit IPM Training Certificate although, for place-bound students who have a job, this would be an unlikely scenario.

Possible workshop offerings at two locations in Washington.

<table>
<thead>
<tr>
<th>Workshop I: Fundamentals of Orchard Ecology</th>
<th>Wenatchee</th>
<th>Yakima/Tri-Cities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workshop I:</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Workshop II:</td>
<td>—</td>
<td>X</td>
</tr>
<tr>
<td>Workshop III:</td>
<td>—</td>
<td>—</td>
</tr>
</tbody>
</table>

* - Optional offering if there is sufficient need.

**Workshop I Outline: Fundamentals of Orchard Ecology**

**The orchard as a natural system**
Principles of ecology - food chains, trophic levels, dispersal and colonization
Orchards as habitats - advantages and disadvantages for insect management
Interactions between plants and insects - nutrition, cover crops, surrounding habitat.

**Fundamentals of identification, arthropod development and life cycles**
Key characters in identification of insects - simple morphology, structure and function
Types of insect development - metamorphosis, developmental thresholds, hormones
Life history strategies - overwintering, dispersal, alternate hosts, multi-year cycles.

**Identification of orchard insects and life histories - Part A**
Key pests that cause direct damage to fruit - codling moth, leafrollers, cutworms, sucking true bugs, pear psylla, oriental fruit moth, lesser apple worm, apple maggot, cherry fruit fly, peach twig borer,
thrips, green fruitworm, scale insects.

**Identification of orchard insects and life histories - Part B**
Secondary, indirect or uncommon pests - aphids, mites, mealybug, leafhopper, shothole borer, scarab beetles, scale insects, leafminers, fall webworm, red-humped caterpillar, grasshoppers.

**Identification of orchard insects and life histories - Part C**
Natural enemies; a general introduction - parasites, predators, diseases.

**Summary and conclusions**
Integration of knowledge to be able to describe organisms present in the orchard system, when they would occur and what the weak links in their life histories might be best to target in order to manage their population with minimal impact on the environment and human health.

**Workshop II Outline: Dynamics, Sampling, Thresholds and Prediction**

**Fundamentals of insect population dynamics**
Biological potential of insect populations, factors determining potential, r-strategists, k-strategists, insect-plant interactions, predator/parasite-prey interactions.

**Sampling theory and practice**
Distributions of insect populations, measuring populations (mean and variance), development of a sampling plan, indirect and direct population estimates, determining sample size, sample precision, binomial samples, sequential samples.

**Application of sampling to actions taken**
Treatment or action thresholds, how they are developed, static versus dynamic thresholds, thresholds available in tree fruit crops and how to apply them, monitoring tools and sampling methods used in tree fruit crops (traps, lures, visual, beating tray, etc.).

**Predicting events in the field**
Models - what they are, their application in IPM, development of phenology models and their application, population models and their application.

**Integration and summary**
Tools used in pest management and those available to the consultant/grower of tree fruit production in Washington.

**Workshop III Outline: Biological Control and Biorational Products**

**Fundamentals of biological control**
Trophic interactions, generalist versus specific natural enemies, principles of classical biological control, value of native predators and parasites, diseases of insects.

**Identification of natural enemies in the orchard system and life histories**
Predatory insects and mites - True bugs (Mirids, Anthocorids, Nabids), Chrysopids (green lacewings), Hemerobiids (brown lacewings), spiders, Phytoseiids (mites), Coccinellids (beetles), Syrphids (flies).

Parasitic insects - egg parasites (Trichogramma), Braconids, Ichneumonids, Aphelinids, Eulophids,
Encyrtids, Tachinids (flies).

**Introduction to biorational pesticides and their modes of action**

Neurotoxic insecticides, JH mimics, ecdysone-agonists, chitinase inhibitors, bacterial insecticides, insect viruses, fermentation products (Avermectin, Spinosad), selectivity of insecticides by mode of action or use pattern, determining impact of pesticides on natural enemies.

**Mating disruption as a fundamental component of an orchard IPM system**

Chemical communication in Lepidoptera and other insects, mechanisms of mating disruption, codling moth mating disruption products, control of codling moth using mating disruption in apple and pear orchards, factors determining the success of mating disruption, other pests of concern in mating disrupted orchards, economics of mating disruption for codling moth, potential of mating disruption as a control for other pests.

**Integration of control tactics in an orchard IPM program**

Designing an IPM plan for an orchard, factors to consider, selecting tactics to use against pests, establishing a monitoring system that is economical yet adequate to describe events in the orchard, contingencies - backup tactics if first line of defense falters, grower’s risk rating, target of fruit sales, warehouse practices, regulations, peace of mind - whose and at what expense.