

Sustainable Orchard Management System For Intermountain Orchards



SUSTAINABLE ORCHARD MANAGEMENT SYSTEM

FOR
INTERMOUNTAIN
ORCHARDS

SARE PROJECT 98-058

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This SOMS handbook was designed to help the orchardist use IPM and fruit-tree phenology to their advantage in producing large volumes of high quality fruit while minimizing inputs. It includes a phenology of fruit trees and pests in a fruit tree calendar, an introduction to integrated pest management, insect and disease fact sheets, and orchard spraying information.

Temperature data generated by orchard weather stations will be used to predict insect and disease occurrence in grower's orchards.

This information will be disseminated to extension workers and collaborators in the project so that they can advise individual farmers of the best time to scout for insects and diseases. They will also give guidance on control measures in the individual states.

INTRODUCTION

Fruit production in the intermountain west is besieged with problems. To cope with these problems, fruit growers must be competent in financing, banking, buying, public relations, marketing, meteorology, climatology, plant science, soil science, entomology, pathology, irrigation, fertilization, chemistry, physics, mechanics, and management. Limits of time preclude grower expertise in each of these critical areas. Therefore, farmers, in addition to their own understanding, must rely on others for many of the things they do. The United States Department of Agriculture Agricultural Research Service (USDA-ARS) and Cooperative Extension Service (CES) have major roles in obtaining and supplying factual information to farmers. US farmers make up a small fraction of society but, through their spectacularly successful efforts, they provide food and fiber for hundreds of people per farmer. Farming success bolstered by USDA-ARS and CES made the industrial and electronic revolutions possible. The burgeoning success of society rests on the agricultural advances of the last century. The remarkable success of food producers has resulted in expectations that food and fiber supplies will never be problematic again. However, this may yet prove to be one of society's greatest future problems.

Farming in the twenty-first century is sophisticated endeavor. Yet, from placement of the seed or plant, to growth and development, on through to food production, the basics remain essentially the same. However, production strategies have evolved to optimize yields while reducing inputs on scales undreamed of in the last century. Orchard management production strategy has also evolved. The introduction of pesticides, herbicides, and hormones during the middle of the twentieth century increased output dramatically. More recently, high-density orchard plantings have resulted in another dramatic yield increase. Integrated pest management (IPM) plans have reduced inputs and have increased production relative to resources used. Today's high density, expensive orchards must have sophisticated operating systems to insure maximum sustainable production over long periods of time. Inputs must be quantified to meet critical needs, and they must be timed for maximum effectiveness. The combination of integrated pest management with phenological timing (phenology is the relationship between the growth and development of an orchard tree and the climatic parameters that affect the trees) should increase orchard production. This combination is called the Sustainable Orchard Management System (SOMS).

INTEGRATED PEST MANAGEMENT IN ORCHARDS

Diane Alston and Michael Reding

1. IPM — WHAT IS IT AND WHY IS IT HELPFUL?

Integrated pest management (IPM) is a concept that has been used in U.S. agricultural industry for about 40 years. It is “*a comprehensive approach to pest management that uses a combination of cultural, biological, and chemical controls to reduce the status of pests to tolerable levels while maintaining a quality environment*”. IPM attempts to combine appropriate and effective pest management tactics to target the problem pests in a crop or other system. IPM combines knowledge of pest biology, control, ecology, economics, and environmental factors to develop crop production and pest management choices for the grower. IPM is an important component of a sustainable farm system.

Key factors of the IPM concept:

- IPM has broad application
 - Can be applied to any ecosystem (orchard, field, livestock, home, etc.)
 - Can be applied to any type of pest (insect, disease, weed, vertebrate, etc.)
- IPM emphasizes an understanding of the system and pests
 - Knowledge of total system (e.g., profitable orchard management practices)
 - Knowledge of pest biology and ecology
- What does IPM integrate?
 - Multiple pest management tactics (biological, cultural, chemical, etc.)
 - Management of multiple types of pests (weed, disease, insect, nematode, vertebrate, etc.)
 - Pest management on a larger-scale (multiple orchard blocks, farm, county, region, etc.)
- Focus is on reducing pests to tolerable levels, not eradication
- Incorporates economic sustainability
 - Implement a control when it is economically feasible to do so
 - Use pest sampling and thresholds to help make decisions
- Can include aesthetic quality of product or system
- Incorporates environmental, human safety, and social concerns
 - Pest controls that minimize negative environmental effects
 - Pest controls that minimize risks to the farm worker and consumer

Key steps in an IPM program:

- **Proper identification of the pest or problem** — Before deciding to take any pest control action, be sure you have correctly identified the pest (insect, mite, disease, weed, vertebrate, etc.) or problem (nutrient deficiency, water imbalance, etc.). Proper identification is essential for determining if control is necessary and for selection of the best-suited control options.
- **Monitor for pests and injury caused by pests or problem** — It is very important to look for pests and injury symptoms on a regular basis. It is best to use a consistent sample or survey method. Monitoring traps for insects, diseases, or vertebrates can be used when appropriate. Sampling frequency will depend on the pest and situation, but a general guideline for many insects and diseases is to sample every 1-2 weeks during the main growing season. Look in the places where pests commonly occur — undersides of leaves, on or inside fruit, on or under bark, on roots, in soil, etc.
- **Control action guidelines** — A grower should develop a set of guidelines for each situation that guides his/her decision-making on unacceptable levels of pest injury. A low level of pest injury can perhaps be ignored if the loss will not justify the cost of control. The economic and aesthetic values of the situation need to be considered, and will most likely be the primary factors driving pest control decisions. Other considerations may be the environmental, social, and worker and public safety costs of pest control decisions.
- **Time pest controls with “windows of opportunity”** — All types of pests have a life cycle or set of

Schematic of the IPM Concept – Building blocks of information allow you to make sound pest management decisions. Informed decisions are dependent on knowledge of the system’s biology.

Toolbox of pest management tactics:

- Biological controls
- Cultural controls
- Mechanical controls
- Chemical controls

Decision-making aids:

- Proper pest identification
- Pest monitoring methods
- Environmental monitoring

- Degree-day models
- Control action guidelines
- Proper timing of controls

Knowledge of Pest / Plant / Ecosystem Biology:



developmental events that occur during their life time. The type of life cycle will vary with the pest. However, most pests have certain weak points or “windows of opportunity” during their life cycle when they are the most vulnerable to control. For insects, these windows are often during the immature life stages or just as eggs are hatching. Weeds are typically easiest to control during their seedling stage, early in the season when they are just beginning to grow (annuals), or late in the season when they are preparing for dormancy (perennials). Diseases are often easiest to control by using preventive or early intervention tactics before the disease pathogen begins developing or becomes established. To optimize management of a pest, control tactics should be targeted for these weak points.

- **Consider all available pest management options and select the “best” ones** — The easiest, lowest cost and often most reliable way to avoid many pest problems is to provide a healthy environment that discourages pest activities and/or reduces the host’s (plant, animal, or ecosystem) susceptibility to damage. In general, such

methods are long-term tactics that may take some time to put into place, but once established help provide more long-term and stable pest suppression. For pests that directly attack essential or yield producing structures of the host (e.g., for plants: fruits, seeds, flowers, stems, trunks), short-term tactics such as pesticides are often the quickest and most reliable pest control option. A combination of both short-term and long-term tactics is often the best approach.

Examples of short-term and long-term tactics:

- | | |
|--|----------------------------------|
| Short-term: | Long-term: |
| Chemicals | Cultural |
| Mechanical disruption | (habitat modifications) |
| (mowing, traps, physical barriers) | Biological |
| | (inoculative, self-perpetuating) |
| Biological | Sanitation |
| (inundative release of a biocontrol agent) | |

[Other IPM Fact Sheets](#)



Orchard weather station



Orchard temperature sensor shelter in tree

2. WHY IS WEATHER DATA SO IMPORTANT?

A pest's immediate environment often determines how successful it will be in attacking and establishing on a host plant. Temperature and availability of moisture (relative humidity and/or rainfall) are the two most important environmental factors for pest development. These factors are also critical to growth and health of the apple tree. Therefore, monitoring and collection of weather data from representative apple production areas are critical to prediction of apple tree and pest development over time. Development over time as influenced by climate is termed "phenology".

Prediction of pest activity is helpful in getting away from the calendar-date-based method of applying pesticides or other control measures. Typically, pest management timings based on actual presence and activity of the pest will result in fewer pest control applications and less cost to the grower. A combination of pest monitoring methods to determine if, when, and where pests occur and predictive phenology (degree-day) models based on important climatic factors (e.g., temperature and moisture) are common ways to determine optimal timing of pest control actions.

Degree-day models for predicting insect development

Like all living things, insects and mites pass through a series of developmental stages (e.g., egg, larva, and adult). Insects and mites are cold-blooded, which means their body temperature is primarily dependent on the temperature of their environment. It also means that the rate at which they pass through their various life stages is dependent on temperature and when it is too cold, no development occurs. As a result, once we know the range of temperatures (usually expressed as the lower and upper temperature thresholds) for development of a particular insect or mite, we can use temperature-based models (degree-day models) to predict this development (also known as phenology). Degree-day models can be used to predict when insects or mites will be active, how fast their populations will build up, or in some cases if they will build to damaging levels. This information can then be used to make decisions regarding when to apply controls or if they are needed.

Research has determined upper and lower thresholds for development of different insect species. Daily maximum and minimum temperatures are collected from the beginning of the calendar year (January 1) in warmer locations, or from the beginning of the growing season (approximately March 1) in cooler locations. There are a number of ways to calculate degree-days. One of the best and most common methods is to fit a curve to the daily temperature fluctuation, and then determine the area under the curve within the boundaries for insect development.

Daily heat units or degree-days can then be added up over time to provide a prediction of the timing of insect activity. Critical degree-day accumulations correspond to “windows of opportunity” to control insect pests such as codling moth, *Campylopus*, white apple leafhopper, and San Jose scale. Pest control actions can then be targeted for these timings based on the presence and developmental stage of the insect pest.

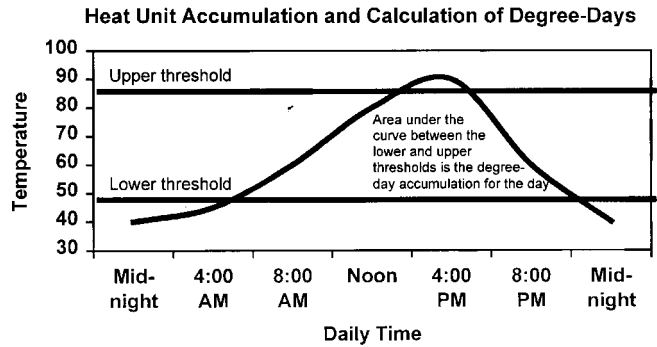
Temperature and moisture models to predict disease development

In apples we use temperature and moisture-based models to predict fire blight (Maryblyt model) and apple scab (Mill’s table model) infection periods.

- The Maryblyt model for fire blight, primarily predicts infection periods during bloom (blossom blight). This model uses average daily temperatures and the presence of moisture (rain or dew) to determine when an infection will occur. Generally, if blossoms are present, the average temperature is above 60F, and moisture is present, an infection period occurs and a bactericide spray is recommended.
- The Mill’s model for predicting apple scab also uses average temperatures and moisture. In this case, the model for predicting an infection period is based on hours of leaf wetness and the average temperature during the wetness period. In general, the higher the temperature the shorter the wetness period needed for infection. The Mill’s table shows the hours of leaf wetness needed for various temperatures to cause a scab infection.

3. ECONOMICS-BASED DECISION-MAKING

Economics is of utmost importance to the grower. A grower cannot afford to take a pest management action without knowing if it is economically sound. Treating a pest needlessly is not conducive to making a profit. And likewise, allowing economic injury to reduce yields and profits more than the cost to control the pest is not a wise financial decision. Other values such as aesthetics of the product (e.g., external appearance of fruit), and environmental and social costs (e.g., clean-up of water sources, pesticide disposal, medical costs for workers, etc.) can play major roles in pest management decision-making.



HOBO data logger in shelter

Fire Blight develops and spreads when:

- b Blossoms are open
- b Average temperature is above 60 F
- b Water or dew and insects are present

[FB fact sheet](#)

Apple Scab develops when:

- b Temperatures are warm
- b Leaves and fruit addet

[AS fact sheet](#)

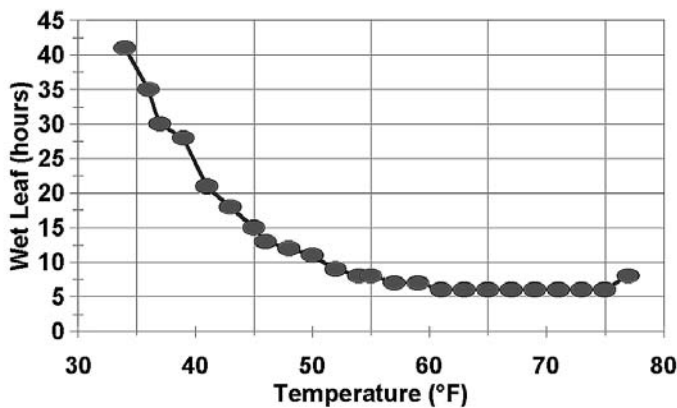
The goal of the practice of economics-based decision-making is to develop and use some **decision-making tools** to assist the grower. Research to determine at what population density or level of plant injury a pest becomes economically justifiable to treat has been conducted for many insect and mite pests. In general, disease pathogens require predominantly preventive controls, where once the pest presence is confirmed, controls need to be implemented fairly quickly. This is also the case for some insects that feed directly on the marketable structures of the crops, such as codling moth which attacks the apple fruit. We call these direct pests. Traps and phenology models should be used to detect the codling moth and determine the optimal timing for its control, but use of a threshold for injury may not be appropriate. The usefulness of treatment thresholds for a direct pest can vary with the grower's objectives, crop production goals, market destination, etc. For example, an organic apple grower may accept up to 5% fruit injury, if he/she can grow the crop without conventional chemicals.



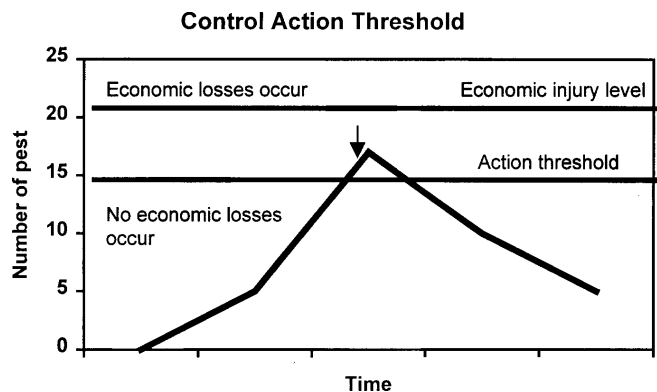
Apple scab on fruit

[AS fact sheet](#)

A **control action threshold** is “the pest density or level of plant injury at which control measures should be implemented to prevent economic loss from the pest”. This concept can be represented graphically as shown below. The arrow indicates when a pest control action is taken. It is important to keep in mind that some pest control tactics require more time than others to take effect, therefore, the control action threshold should be adjusted to accommodate this lag time.



Hours of leaf wetness for scab infection at different temperatures



4. PEST MANAGEMENT OPTIONS

Many different types of pest management tactics are available for different types of pests. They can be grouped into categories such as cultural, mechanical, biological, and chemical. It was mentioned earlier that some tactics reduce pests quickly on a short-term basis, and others are more appropriate for a long-term approach. A good mixture of both types often results in the most effective, most stable, and most sustainable pest management program. And remember, an IPM approach is not focused on pest elimination, but on reducing pest densities to tolerable

levels. In addition, many pest management tactics are part of a sustainable crop production program geared towards maintaining healthy orchards that are tolerant of many stresses caused by pests, the environment, and other factors.

Specific tactics appropriate for each type of pest are discussed in the individual pest fact sheets, however, below is a brief discussion of general tactics.

Examples of general pest management tactics for apple orchards:

- **Cultural controls**

- o Water/irrigation management – Avoid over- or under-watering trees to minimize plant stresses and make the environment for the pest as unfavorable as possible.
- o Sanitation – Remove (prune, gather, burn) plant parts and debris that can harbor pests both within a growing season and over the winter.
- o Pruning – use pruning practices that enhance tree health and minimize pest populations (e.g., excessive pruning can stimulate growth and increase pests like fire blight and aphids).
- o Removal of water sprouts and root suckers – tender foliage on sprouts and suckers can attract and harbor pests, such as powdery mildew, mites and aphids.
- o Habitat diversification – Diversification of vegetation in an orchard habitat may subsequently increase the diversity of animal life in the orchard. Because such diversification may attract and harbor beneficial as well as pest organisms, the specific approach should be tailored to the specific situation.
- o Tolerant/resistant species and cultivars – Select trees with resistance or tolerance to insect and disease pests in your location whenever they are available. Select winter-hardy rootstocks and scions to reduce winter damage that may make trees more susceptible to disease and insect pests.
- o Soils and nutrition – Although you cannot change the soil type in an orchard, there are some practices you can follow to improve growing conditions for apple trees. Proper fertilization is important, but over-fertilization can lead to excessive, lush growth that can be attractive to aphids and other foliage pests. Increasing organic matter of soil where it is low and preventing nutrient disorders, such as iron deficiency, can be important tree care practices in the Intermountain West.

- **Mechanical controls**

- o Hand removal – Mechanical removal of some pests may be feasible for small-scale orchard production, but is probably not practical for larger orchards.
- o Mowing – Mowing down weeds, especially before they produce seeds, can be an effective management tool.



High density apple orchard



Counting pests in Pheromone trap



Wooley Apple Aphid
Lady Bug predator

Pests:

- b Direct – attack fruit
- b Indirect – attack leaves on trees

- o Traps – Attractive traps can be used to mass trap and remove pests from an orchard or to monitor their activity so that control actions can be appropriately timed. Traps are primarily used for insect and vertebrate pests, and for some disease pests. Attractive traps typically use visual cues (color) and/or odors (pheromones, food baits) to attract pests to them. Passive traps may be placed in areas of common pest activity or use wind currents to catch pests.
- o Trunk bands – trunk bands made from corrugated cardboard are a special type of trap designed to concentrate overwintering codling moth larvae where they can be destroyed.
- o Physical barriers – Barriers can be used to block or disrupt the movement of pests.

• Biological controls

- o Predators – an organism that eats or consumes another (e.g., predatory insects and mites)
- o Parasites – an organism that lives in or on another and kills it (parasitoid) while completing its life cycle (e.g., parasitic insects)
- o Pathogens – microbial organisms that attack and invade other organisms (e.g., bacteria, viruses, nematodes), or out-compete other plant pathogens for space or resources on the plant surface
- o Herbivorous insects of weeds – plant-feeding insects that attack weeds

The predominant way in which biological control agents have been used successfully in orchards is by encouragement and enhancement of those that occur naturally (or were introduced at one time, but now colonize new environments on their own). Many predators, parasitoids, and pathogens occur naturally and are continually working to help keep nature in balance. The importance of “natural enemies” is often not appreciated until a broad-spectrum pesticide, which kills many beneficials as well as the targeted pest, is applied and a new pest – suddenly released from biological control – becomes a serious problem. Some good examples of this type of pest, which is termed a **secondary pest**, are spider mites and aphids. In most cases, the purchase and release of a biological control agent into orchard environments, either with an inundative release (flooding an area with high densities of the agent to reduce the pest in the short-term) or with an inoculative release (release agent over a period of time to help it colonize and spread) have not proven effective. An exception to this is the inundative application of microbial agents that will compete with detrimental plant pathogens on the apple tree surfaces.

The greatest assistance a grower can provide to natural biological controls is to avoid activities that are antagonistic to the control agents and to adopt practices that encourage the agents. Some examples are: use selective pesticides and target them to pest-problem spots; provide a habitat that is more favorable for natural enemies

by choosing adjacent plants that supply nectar, pollen, alternate hosts, and structural protection; avoid complete removal of habitat for beneficials (ground covers, border vegetation); and provide adequate organic matter in soil to ensure good habitat for soil microorganisms that control a variety of pests, particularly soil pathogens and root-feeding nematodes.

- **Chemical controls**

A **pesticide** is “any substance applied to control insects, fungi, bacteria, weeds, vertebrates, or other pests”. Since the advent of “synthetic” pesticides in the 1940’s, growers have become very reliant on their generally simple-to-use, fast-acting, and effective attributes to manage the majority of pest problems. In recent times, resistance of pests to pesticides because of their high use has become a major problem. To reduce the reliance on pesticides as a single-pronged approach to pest management, growers should become more familiar with all types of pest control tactics, so that the “best” ones (most effective, least environmental and human safety impacts, most cost-effective) can be selected for each situation. Although pesticides have perhaps been over-used in recent decades, they still remain an important tool in the pest management toolbox. Avoidance of overuse will allow them to remain as viable pest control tools for many more decades to come.

Many types of chemicals used before the development of synthetic pesticides are now becoming popular once again as alternative or “organic” pest controls. In addition, many new chemical products are being developed, such as biologicals, pheromone-based mating disruption, and insect growth regulators. The U.S. Environmental Protection Service is encouraging the development of more selective and “softer” pesticides through its product registration and renewal programs.

- o Synthetic pesticides – human-made in the laboratory; chemically joined compounds or elements
- o Organic pesticides – derived from plant, animal or naturally occurring rock or petroleum oil sources
- o Biological pesticides – a subset of organics that specifically refer to products developed from living microbial agents, such as bacteria, viruses, fungi and protozoa
- o Insect growth regulators (IGRs) – chemicals that mimic natural growth regulators in insects; they interfere with the normal processes of insect growth and development

Pheromone-based mating disruption

Insect mating disruption technology has greatly expanded in the last decade. This insect control technique has proven very successful under certain conditions and is now used on large acreages of apples in the Pacific Northwest for control of codling moth. The large reductions in use of synthetic pesticides in these apple-producing areas has resulted in enhanced biological control and improved management of



PAK Tank herbicide sprayer



Keeping the tree row weed free combined with a grass cover crop will help in controlling some insects



Chemical storage and safety equipment

[Storage facility fact sheet](#)



Isomate C Dispenser



The "business" end of an air-blast sprayer

many secondary pests, but also in the release of some insect pests from insecticide control, such as leafrollers.

The technology relies on the release of high concentrations of a synthetic chemical mimic of the insect's sex pheromone to confuse or disrupt mating behavior of the targeted insect. It has been found that mating in codling moth populations is greatly delayed under mating disruption programs, and so very few viable eggs are produced. Improvements in the dispensers and application technology have moved this insect control program to the forefront for codling moth control in the Pacific Northwest. However, the conditions under which the technology performs well do not apply to all fruit growing areas. The size of the orchard, proximity to outside sources of mated codling moth, and dispenser placement and application rate can all have major influences on the success of this tactic. The typically small size of apple orchards in the Intermountain West and Southwest (2-10 acres) and the high codling moth populations reduce the effectiveness of mating disruption in these areas as compared to other areas in the West. Therefore, those growers who are interested in using mating disruption should consider the factors discussed above that will increase the likelihood of success, and proceed with caution. A change-over to the use of mating disruption from a primarily synthetic chemical program requires a transitional period where synthetic insecticides are slowly phased out.

Delayed dormant oil sprays

A key time to control pests (insects and diseases) that overwinter on apple trees is during the delayed dormant period. Examples of these types of apple pests are powdery mildew, apple scab, aphids, European red mite, and San Jose scale. The delayed dormant timing comes just as the apple leaf buds begin to swell and open in the spring. A superior-type dormant oil applied at this time in combination with the appropriate chemical for control of the targeted pests can provide good early-season pest control and prevent early-season stresses to the apple tree. Some other benefits to delayed dormant applications are that they have minimal negative effects on natural enemies if applied correctly, and target the oil to sites where pests are concentrated. The mode of action of oil is by suffocation, and so development of pest resistance to this type of chemical is unlikely.

Pesticide resistance

The overuse of pesticides has led to the development of resistance in the target pests. Pesticide resistance has occurred in many types of pests, including diseases, weeds, insects and mites. It makes sense that when an organism is repeatedly exposed to a certain type of chemical, that it can develop a tolerance to it. Resistance has not only been shown to occur for a specific chemical, but cross-resistance to other chemicals with a similar mode of action can also occur. Cross-resistance in a pest has even been demonstrated across classes or types of pesticides.

Therefore, wise and judicious use of chemicals is critical to promotion of their long-term effectiveness. Good chemical use practices include selecting non-chemical alternatives whenever feasible, rotating between different types of chemicals, applying chemicals at the labeled rate so as to not over-dose or under-dose, and getting good coverage to ensure exposure of all pest individuals in the population to the chemical. Failures in chemicals to control pests can result from resistance, but failures more commonly result from problems associated with application, such as incorrect rate, inadequate coverage, or improper timing.

5. FITTING IT ALL TOGETHER: PRACTICING IPM IN THE APPLE ORCHARD

The components of an IPM program may seem numerous and complex. However, a strong advantage of using an IPM approach over a straight conventional chemical approach is that IPM offers many options and is robust in its ability to accommodate specific situations. Even though there are many similarities across apple orchards in the western U.S., each orchard presents a unique situation with unique considerations. Therefore, under an IPM program a grower has many choices to select from to tailor a pest management program that is ideal for his/her situation.

The underlying foundation of a solid IPM program is knowledge of the crop system and pest biology. The second step is obtaining quality information about the occurrence and abundance of pests in the crop system. An IPM program is information-intensive. This intensity of information can be a deterrent for growers who feel their hands are already full with managing the apple production, farm-worker, and marketing aspects of the operation. Time invested in gathering quality information does pay off in the end when fewer control tactics need to be implemented, the timing of control practices is improved so that pest control is enhanced, fewer pesticides are applied or at least fewer broad-spectrum chemicals that have negative effects on natural enemies, and more time is spent learning about the biology of the system rather than trying to kill unwanted pests. An IPM program fits into an overall sustainable orchard management program that emphasizes working with the system rather than fighting against it.



"King Bloom" open-laterals still not opened



Full bloom in apple

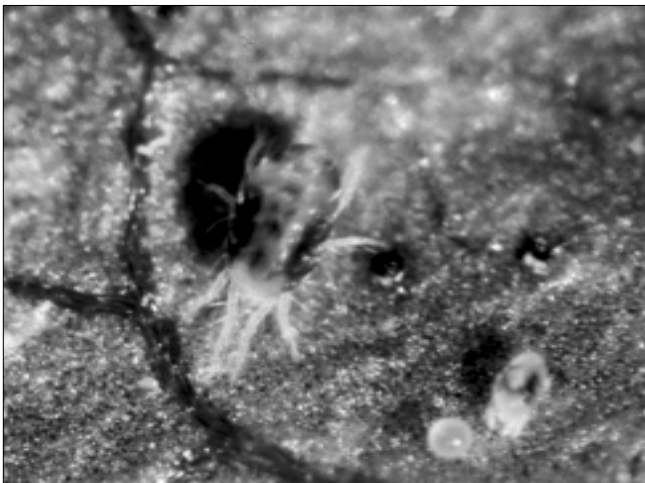
IPM ON APPLE: MOST IMPORTANT INSECT/MITE PESTS AND SYNOPSES OF CONTROL MEASURES



Codling moths in sticky trap



Codling moth frass



Two spotted mite adult, juvenile, egg

CODLING MOTH (pest of apples and pears)

- Key pest of apple in the western United states.
- Damaging stage: worms, larva tunnels, and excrement in Fruit.
- Use pheromone traps to monitor male moths and set biofix.
- Degree-day (DD) model used to time sprays based on biofix.
- Optimum time for first cover spray is 250 DD after biofix.
- Second cover spray is applied based on the residual period for the chemical.
- Time third cover spray at 1260 DD after biofix.
- Guthion and Imidan are the most effective insecticides for controlling codling moth.

[CM fact sheet](#)

See fact sheet in back of manual for more information.

TWO SPOTTED AND McDANIEL SPIDER MITES: (pests of most tree fruits)

- Invade tree from the groundcover.
- Mites build up on broadleaf weeds in the ground cover, grass is a good groundcover to help prevent mite build-ups.
- Mites feed on leaves causing white speckling, bronzing, and defoliation.
- Tree vigor, fruit color, fruit size, and production can be reduced.
- Mites can be highly destructive during hot summer months.
- Begin scouting in mid-June
- To sample, select 10 trees and collect 10 leaves (inside to edges of canopy) from each tree.
- You do not need to count the mites on each leaf, just determine if mites are present or not.
- If 7 or less leaves out of 10 have mites and at least 5 out of 10 have predators, re-sample in 2 weeks.
- If 8-10 leaves out of 10 have mites and at least 5 out of 10 have predators re-sample in 1 week.
- If 10 out of 10 leaves have mites and less than 5 out of 10 have predators, consider applying a miticide.
- Agri Mek and Pyramite are miticides that are generally effective against mites and soft on predators.

[SM fact sheet](#)

See fact sheet in back of manual for more information.

EUROPEAN RED MITE (pest of most tree fruits, especially apples, pears, and cherries)

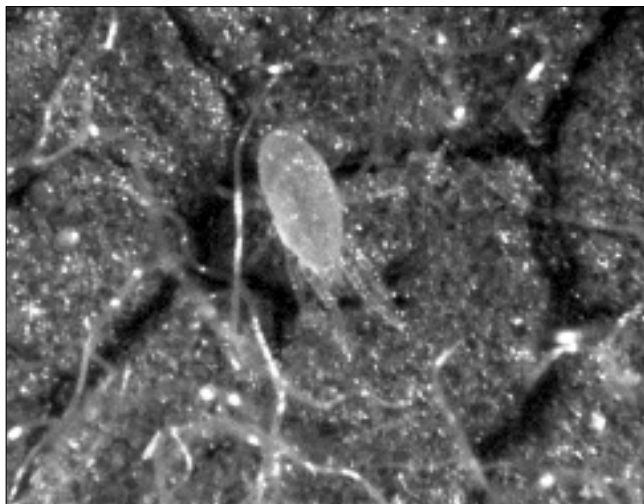
- Remain in tree year round.
- Mites feed on leaves causing white speckling, bronzing, and defoliation.
- Tree vigor, fruit numbers, color, fruit size, and production can be reduced.
- Mites can be highly destructive during hot summer moths.
- If the orchard has a history of red mites, apply a Superior type oil (dormant oil) at half-inch green.
- Dilute sprays of 200-400 gal/acre are most effective, 1- 5 gal of oil per 100 gal of water.
- Good coverage is critical, the oil must cover the overwintering eggs.
- Scout for post bloom populations starting in late May
- For miticides and treatment thresholds see web spinning spider mites above

ERM fact sheet

See fact sheet in back of manual for more information.



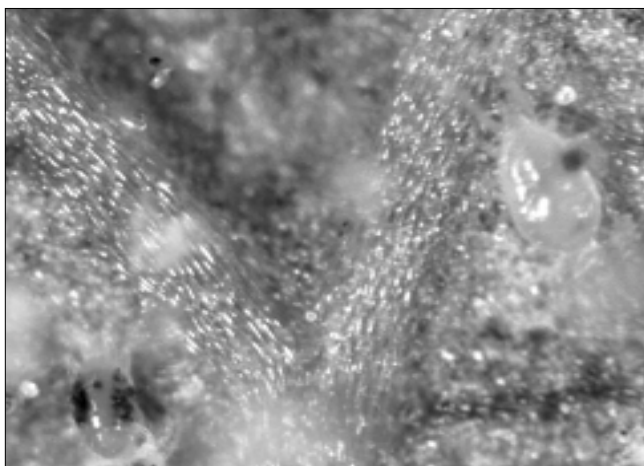
Two spotted mite webs



Predator mite



Red mite eggs on apple bud



Predator mite

CAMPYLOMMA (pest of apples, especially Golden Delicious, Red Delicious, Gala, and Fuji)

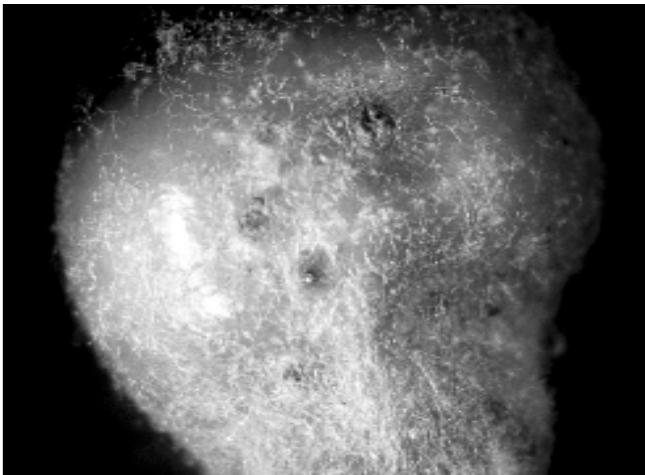
- Scout with beating trays.
- Begin scouting between pink and bloom.
- Hit a tree limb 3 times with a padded stick or dowel, catch the insects on the tray, and count the campylomma; sample 20 trees per block.
- Treatment threshold for Golden Delicious is 1 or more nymphs per 20 trays by bloom.
- Treatment threshold for Red Delicious is 1 or more nymphs per tray by bloom.
- Thresholds have not been established for Gala or Fuji, but their sensitivity appears to be intermediate between Golden Delicious and Red Delicious.
- Treatments applied by late bloom are most effective, treatments after bloom are not as effective and generally do not prevent unacceptable levels of damage.
- Prebloom: Carzol, Lorsban, and Thiodan are effective.
- If the orchard has a history of campylomma, Lorsban in the delayed dormant treatment provides some control
- Bloom: Only Carzol can be used and must be applied at night to protect bees.

[CB fact sheet](#)

See fact sheet in back of manual for more information.



Campyloma bug



Campyloma bug damage on apple

WHITE APPLE LEAFHOPPER

- Primarily a nuisance pest, causes picker annoyance.
- Does not damage tree or affect fruit quality.
- Two generations a year, control the first and the second will be small.
- First generation can be controlled by thinning sprays of Sevin at petal fall or
- Provado added to the first codling moth cover spray.

[WALH fact sheet](#)

See fact sheet in back of manual for more information.

APPLE APHIDS (Primarily pests of apple)

Green Apple Aphids

- Build up slowly in spring, colonies are generally not noticeable until mid-June or later.
- Begin scouting in mid-June and scout for colonies about every 2 weeks or so.
- Feed on flush growth of terminals and produce a sticky substance called honeydew.
- Aphids are only a problem on established trees when colonies become so large that honeydew drips onto the fruit.
- Aphids have a lot of natural enemies, check colonies for lady beetles, lacewings and syrphid larvae. These predators will often reduce aphid numbers to tolerable levels.

Rosy Apple Aphids

- Generally build up from pink to about mid-June, then they leave orchards for other hosts.

Both aphids overwinter as eggs on the tree. Window of opportunity for control is at delayed dormant (half-inch green). Apply a dormant oil plus an organophosphate such as Supracide or Lorsban (also controls campylocoma). During summer Provado is an effective treatment.

[Apple Aphid fact sheet](#)

See fact sheet in back of manual for more information.

OTHER PESTS: *See fact sheets in back of manual.*

San Jose Scale

Western Flower Thrips

Western Tentiform Leafminer

Disease fact sheets:

[Apple scab](#)

[Crown rot](#)

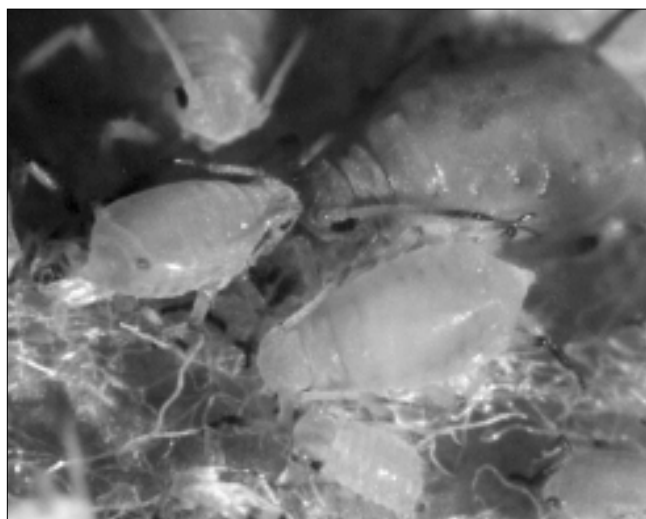
[Fire blight](#)

[Iron chlorosis](#)

[Powdery mildew](#)



Leafhopper



Apple aphids

Economic Threshold (ET)

Pest control can be achieved best when the grower knows what pests are active in his orchard. This requires looking for the pests (scouting) when weather data indicates they may be present. The value of the phenological approach is in the ability to predict when scouting is needed because pests may be present. Once the pest has been identified, control measures can begin. It is counterproductive to spray for pests when they first are found in the orchard. Their numbers may never rise to a level that will cause economic damage. Natural predators may provide control. Scouting should monitor the pest and predators of the pest. ET for specific pests depends on predator levels. When pest numbers are high without correspondingly high numbers of predators, control may be needed. However, when pest numbers are high and predator numbers are also high, predators may provide the control and artificial control methods may not be needed. It is important to know the economic threshold level, the level at which the damage or crop loss becomes greater than the cost of control. And it is important to remember that threshold levels may change due to predator populations.



Economic thresholds will usually be lower for pests that directly attack fruit. Pests that attack leaves, bark, or shoots can cause indirect damage when photosynthesis is decreased due to decreased productive foliage in the orchard canopy. Codling moth is an example of a direct pest that attacks the fruit while western tentiform leafminer causes indirect damage. When a codling moth attacks a fruit, a cull results, but when a tentiform leafminer reduces the photosynthetic apparatus by mining a leaf the damage is not as serious.

Sustainable Orchard Management Spraying

Avoid spraying if possible; when population pressures are not at economic levels or if natural predators or softer solutions are available to gain control. If you must spray to protect your crops, identify and spray problem areas only and make sure that you get complete coverage in the target area.

CALIBRATE YOUR SPRAYER

Orchard sprayers should be adjusted to cover trees uniformly. Spray solution should never be directed at air space above trees. With large trees about 2/3 of the sprayer output should be in the top 1/3 of the spray blast area. With smaller than seedling size trees the formula changes. In high-density dwarf tree orchards, spray may be placed best with high-pressure sprayers that utilize fan type nozzles and apply the spray directly to the tree with pressure rather than an air blast. In that case, sprayers are calibrated the same as herbicide sprayers.

ADEQUATE COVERAGE

Modern orchard spraying is done with Tree Row Volume (TRV) calibration. The calculations are made as follows:

Calculate the tree canopy “box” first:

$$1. \quad TRV = T_h \text{ (ft)} \times T_w \text{ (ft)} \times 43560 \text{ (ft}^2\text{)}/TS_{rm} \text{ (ft)}$$

Where T_h = tree height, T_w = tree width, and $43560 \text{ ft}^2/TS_{rm}$ = tree row distance in an acre calculated by dividing square feet in an acre by the tree space in the row middle.

In a high-density orchard this value will be somewhere between 300,000 to 600,000 cubic feet.

Calculate the gallons of spray needed per acre to wet the trees second:

2. Trees do not uniformly fill up the orchard space. Therefore, a density factor (DF) that estimates the percentage of the $T_h \times T_w \times T_{rm}$ box that is filled by foliage is used to adjust for canopy spaces not filled. This factor ranges from 0.6 to 0.9 depending on the tree hedgerow conformation. This is divided by 1000 ft^3 , which represents the average leaf volume covered by a gallon of spray solution.

$$\text{Gallons of spray/acre (GPA)} = (TRV \times DF)/1000$$

Calculate the gallons per minute for each side of the sprayer third:

3. Gallons per minute/side of sprayer (GPM) is the next thing to determine

$$\text{GPM / side} = ((\text{GPA} \times \text{MPH} \times TS_{rm})/1000)/2$$

Where GPA = gallons per acre, MPH = miles per hour (usually 1.5 to 2) and

TS_{rm} = tree space row middle

Nozzle the sprayer for this gallonage fourth:

4. The “spray technician” goes to the manual of the sprayer used to nozzle the sprayer to deliver the appropriate gallons per acre per side in the appropriate geometry to deliver uniform coverage. Gallons per minute for different nozzle sizes are given in the sprayer manual at various delivery pressures. Good pressure readings are necessary for proper calibration.

$$TRV = T_h \times T_w \times 43560 \text{ ft}^2/TS_{rm}$$

$$GPA = (TRV \times DF)/1000$$

$$\text{GPM/side} = ((\text{GPA} \times \text{MPH} \times TS_{rm})/1000)/2$$



Target pole in tree for spray distribution

Spray deposition patterns can be evaluated with water sensitive paper targets (Gemplers, www.gemplers.com, water sensitive 2 x 3" yellow cards turn blue when wet) held with clothes pins taped or glued to 1" schedule 40 PVC pipe at 1 foot intervals. In a pinch, 3 x 5 inch coated cards will do. This "target pole" is placed in the center of the tree. The tree is sprayed normally, and the deposition pattern is estimated from the watermarks on the papers. Adjustments in nozzle sizes can be made to equalize chemical distribution throughout the tree canopy and block off any jets aimed above or below the trees. With large trees about 2/3 of the spray needs to exit the upper 1/3 of the nozzle bank. With small trees it pays handsome dividends to "aim" the spray solution to get uniform tree coverage.

Orchard spraying is best when:

1. Sprayer speed is 2 miles per hour or less.
2. Spray is applied when winds are below 5 mph.
3. Sprayer has been calibrated properly.
4. Nozzle and air blast pressures are low in order to avoid spray particles that will not impact on plant material.

Tractor odometers are usually not accurate. Pace off and mark 30, 45, and 60 three-foot paces.

If your sprayer passes 29 paces per minute your mph » 1.0

If your sprayer passes 44 paces per minute your mph » 1.5

If your sprayer passes 58 paces per minute your mph » 2.0

Adjust your accelerator to move your sprayer 2 mph. Mark this adjustment.

Speeds faster than 2 mph result in decreased spray deposition on the canopy.

ALTERNATE ROW MIDDLE SPRAYING

In large orchards good insect control has been obtained by spraying every other row every other time. Of course, each spray needs to be applied to the outer rows of the orchard due to the higher insect and disease impacts occurring there. To incorporate this strategy into your orchard spraying, experiment with it on a small-scale one year and if it works for you increase areas sprayed in subsequent years.

DIRECTIONAL VS AIR BLAST SPRAYING

In high-density hedgerow systems, directional high pressure spraying, like that used for weed sprays, using booms located close to the tree canopy periphery can be very effective. Calibration, similar to weed spraying with a boom, is really important with directional spraying.

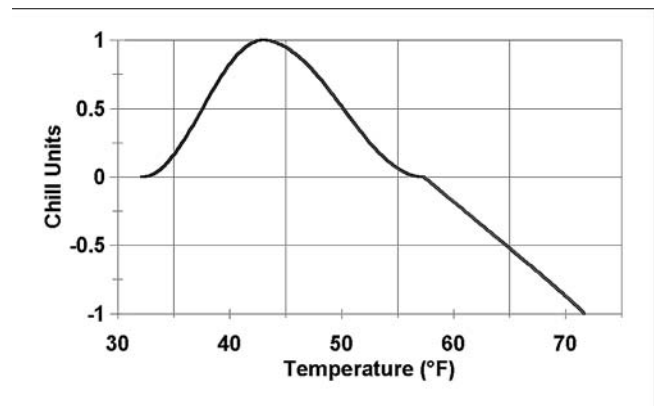
THE FRUIT TREE CALENDAR

Temperate-zone climates have variable seasons from year to year. Falls and winters may be harsh or mild, springs may be warm or cold, and summers may be cool or hot, and the annual weather cycle can be various combinations of the above seasons. The most constant characteristics of the weather in this zone are variability and change. As a result, perennial plants, which have developed mechanisms that allow them to survive seasonal variability, have developed to respond to environmental cues that regulate their growth and development. Estimating tree status from the standard calendar in such variable season to season and year to year weather results in wide variations in time for various tree growth and developmental stages. This variability is especially true of tree fruits. However, when tree growth and development are related to their environmental driving factors in the mode of a tree/environment calendar, the variability significantly diminishes.

Tree growth and development simply does not follow the standard calendar. In some years apricots complete their dormancy early and start growing in January. Usually, depending on extent of growth, these apricot flower buds succumb to subsequent freezes. In other years, when the weather is colder, they do not begin to develop until much later. Apples, on the other hand, have a long dormancy period and usually do not begin to grow until late February or March. The dependency of perennial fruit trees on changes in the weather from year to year illustrates the fact that a fruit tree calendar should be characterized by plant response to influencing weather parameters rather than to days of the standard calendar.

A fruit tree calendar, like the standard calendar, needs to have a good, dependable starting point. The starting point could be first bud swell in late winter, full bloom in the spring, fruit maturity in late summer or early fall, or leaf fall in the fall. Selection of the starting point needs to be done according to the needs of fruit growers to solve problems associated with fruit production. Environmental parameters influencing trees have been identified and quantified. Mathematical expressions of how these influencing factors affect the growth and development of a tree have been developed. The resulting models of growth and development have been calibrated through several seasons. From these models, a fruit tree calendar starting point has been determined.

The fruit tree calendar, developed at Utah State University, begins on September 1st of the standard calendar. From that point on, tree growth and development are related to weather influences on the tree. In the temperate zone, there are many reasons to begin the fruit tree calendar in September. The most important one is that trees enter dormancy in late summer and dormancy completion is temperature dependent. Temperatures in late summer and fall in the temperate-zone decrease over time: this decrease has predictable effects on fruit trees and can be used to time



The temperature response curve for Chill Unit Accumulation during dormancy

1 Chill Unit Equals 1 Hour at the Optimum Temperature

the beginning of the fruit tree year. From this beginning time, fruit tree development and growth – dormancy, bloom, fruit growth and development and related biological phenomena – can be estimated from models. Over the past few decades these models have been calibrated, and can now be used as the basis for the fruit tree calendar.

Dormancy completion is driven by one environmental parameter – temperature. In fruit trees dormancy is not greatly or directly affected by daylength, light or light quality, precipitation, relative humidity, or other climatic parameters. As the result of being dependent on only one driving factor, the dormancy model is simple, and simple models are easy to understand and implement. As average temperatures decrease in late summer and fall, dormancy is induced and the fruit tree calendar begins. After dormancy is completed, trees gain the ability to grow in response to temperature. The phenology of fruit tree flower anthesis, period of opening, has been modeled in detail.

There are three current Utah models of fruit tree growth and development that depend on environmental phenomena to measure the tree's status during their annual cycle. They depend on ambient temperature during the winter and early spring and on solar radiation and temperature during spring and summer. They are:

1. The Utah Chill Unit Model, the dormancy model, which numerically accumulates *chill units* – the driving force of dormancy transition,
2. The Utah Anthesis Unit Model, the flowering model, which numerically accumulates *anthesis units* – the unit for measuring flower bud opening, and
3. The Utah Growth and Development Unit Model, the growth model, which numerically measures *growth units* - foliage development, shoot growth, and photosynthesis potential through late spring and summer.

THE CHILL UNIT MODEL

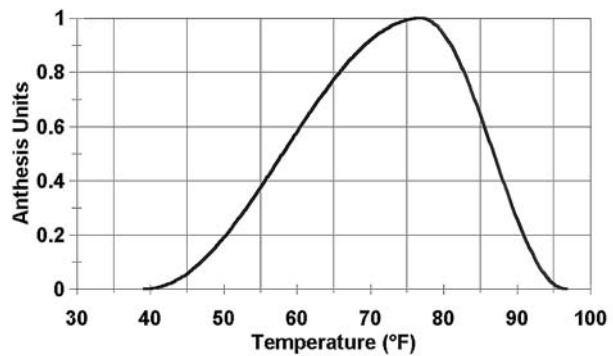
The Utah Chill Unit Model uses *chill units* to measure fruit tree dormancy development during the fall and winter. A *chill unit* is one hour at the optimum chilling temperature for dormancy development. Orchard trees require time at temperatures between 0 and 15 °C (32 and 60 °F) to complete the dormancy portion of their annual cycle. Temperatures below 0 °C (32) do not contribute to dormancy completion. Temperatures above 15 °C (60) may cause negation of previously acquired *chill units*. The dormancy temperature response curve is most effective between 4 to 7 °C (40 to 45 °F) with other temperatures between 0 and 15 °C (32 and 60) being only partially as effective. Most orchard trees share a common chilling temperature response curve. The response curves through time for some common orchard trees as determined in various experiments are shown in the chill unit Figure. At high temperatures, *chill units* are negative. As the seasons progress from late summer to early fall, temperatures

decrease and the average temperature drops into the *chill unit* curve area. When *chill units* are accumulated or summed for each day during the late summer and early fall they go negative initially until the average temperature drops into the *chill unit* curve region. Then positive *chill units* begin to accumulate. The point of maximum negative *chill unit* accumulation is temperature dependent and can be identified on a plot of *chill units* during the summer to fall transition. This maximum negative *chill unit* accumulation marks the beginning of dormancy development. Different species and cultivars have characteristic chilling requirements. Once the chilling requirement has been completed, dormancy is over, and trees have gained the ability to grow in response to temperatures above the growth threshold.

THE ANTHESIS (FLOWER DEVELOPMENT) MODEL

After dormancy completion, trees respond differently to temperature. They grow in response to temperatures above a threshold close to 5 °C (42 °F). The optimum temperature for growth, the temperature that provides the fastest growth, is around 25 to 30 °C (77 to 86 °F). Growth rates decrease above 30 °C (86 °F) and growth stops somewhere around 35 °C (95 °F). The general temperature response curve for flower and leaf bud development of most orchard species is shown here. An anthesis unit is defined as one hour at the optimum temperature for flower bud growth and development. Temperatures above the threshold but below or above the optimum provide fractional *anthesis units*. The relationship between bud development and flowering and temperature has been developed for fruit trees. The number of *anthesis units* for each stage of bud development has been determined. Therefore, temperature data can be used to determine the developmental stages of fruit trees from the end of dormancy through the various stages of bud development to full bloom. A grower can keep track of the development and growth of his orchard trees by summing the *chill units* day by day until dormancy has been completed and then summing the *anthesis units* day by day through various stages of flower bud development to full bloom.

Predictive capability is possible when growers have long term weather normals for their area. Long-term weather normals are the maximum and minimum or hourly temperature averages over a long time period, usually 30 years. The end of dormancy can be predicted by summing the chill units to the last day of collected current season data in the orchard, then long-term normal data can be used to make an estimate of when the end of dormancy will occur. Bloom stages can be predicted in the same way. As the end of dormancy or bloom approaches, accuracy of the prediction gets better because more current data and less historical normal data are used in the prediction.



The temperature response curve for anthesis unit accumulation

1 anthesis unit equals 1 hour at the optimum temperature.

$$\begin{aligned} \text{LAI} &= \text{Leaf Area Index} \\ &= \frac{\text{ft}^2 \text{ Leaf Surface}}{\text{ft}^2 \text{ Ground Surface}} \\ \text{Optimum} &= 5-6 \end{aligned}$$

Full bloom is an important event in orchard growth and development. It marks the completion of flowering of flower buds that had their beginnings during the previous summer. It is the most hazardous time of the fruit tree year because of freeze susceptibility, weather influences on pollinators, and the tendency of fruit trees to bear more fruit than they can support. Weather around full bloom is important not only for pollinator activity but for leaf development and the resulting photosynthesis. Energy for bloom and fruit growth and development before, during and immediately after bloom comes from reserves stored in the plant during the previous year. If weather in the previous year was sufficient for growth, development, and photosynthesis, then sufficient quantities of photosynthate will be available to support early growth. If the previous growing season was unfavorable, then anthesis and early growth and development will be weak. Trees do better after a good growing season and poorly after a poor growing season, and the effect of a poor season may be seen for several subsequent years. Therefore, condition of the tree around full bloom that is highly important for fruit set and early development is dependent on the tree's history over the past few growing seasons.

[Fruit calendar presentation](#)

HOW CAN FRUIT GROWERS INCREASE THEIR INCOME?

The goal of a SOMS program is to increase the fruit grower's income by increasing production and decreasing per acre production costs with integrated orchard management. Fruit production is a function of planting density and dwarf tree precocity. Its limits are set when the fruit grower selects the orchard site, rootstocks, cultivars, and training and cultural systems. Modern high-density orchards of 700 to 1,000 size-controlled trees per acre in single rows provide early cropping and high yields. Yields in excess of 2,000 boxes per acre are not uncommon and can be reached 5 years after planting. Such yields require only minimally increased per acre irrigation, fertilization, protection, and spray applications. Concentration of production on fewer acres allows more attention to a smaller but much more productive area. The result is decreased production costs per box of fruit and more return to the grower. As growers rotate their orchard tree blocks, they should carefully select the best cultivars and have them grafted onto size controlling rootstocks. These trees should be planted in single-rows at densities of up to 1,000 trees per acre or in three to five row beds where greater densities are desired and justified by grower expertise.

The profit equation in fruit production is:

$$\text{Profit} = (\text{Net Yield Per Acre} \times \text{Price Received}) - \text{All Production Costs}$$

The following information concerning orchard architecture is given here because of the importance of planting competitive orchards. Fruit production is a long term

investment. Modern orchards must be structured so that they produce the maximum amount of fruit for a minimum amount of expenses. It is far better to have 10 acres of trees producing 2,400 boxes per acre than to have 40 acres of trees producing 600 boxes per acre. Consideration of the profit equation tells the grower why.

Today's fruit growers compete on a worldwide market. Wholesale prices are set by supply and demand and the individual grower can do little to affect them. Retail prices are also set by supply and demand, but quality fruit sold at the farm to individual consumers can bring higher prices if the grower is willing to establish a clientele. For most growers, however, this outlet is limited. Production costs, like wholesale prices, are determined by the cost of each individual commodity required for orchard cultural practices and are governed by forces beyond the grower's control. Therefore, the grower can increase his profit only by increasing Net Yield Per Acre in a manner that lowers production costs per bushel produced. Lower production cost per bushel is the objective of SOMS.

Higher net yields and lower production costs per bushel are characteristic of high density dwarfed plantings because of the positive characteristics of small trees:

POSITIVE CHARACTERISTICS OF SMALL TREES:

Better light distribution:

Small trees produce their canopies in 3 to 5 years and present the canopy to full sunlight. Tree widths are limited to 6' and heights to < 12'.

Higher productive leaf area:

One hundred percent of the foliage is exposed to sufficient sunlight in small trees to generate plant foods. Growth during the season does not shade-out foliage.

Higher early yields and higher orchard-lifetime yields:

The greatest advantage of small trees is the crops produced in the 2nd, 3rd, and 4th years in the orchard. By the 5th leaf, the trees are producing full crops. If planting density is correct, yields of 80+ bins per acre can be realized.

Higher quality fruit:

Fruit quality is excellent on small trees because leaves are nearly 100% efficient, exposure to sunlight is greater, and logistics of food and nutrient translocation is better.

Less pruning:

Small trees produce fruit, not wood. Less wood produced means less pruning. However, training becomes very important with the small tree.

Lower chemical costs per bushel:

Small trees cover the orchard floor faster with higher leaf surface area that provides greater yields. Since chemicals are applied on a per acre basis to a greater number of bushels of fruit, cost per bushel is lower.

Better spray distribution:

Spray penetration is much better in the smaller canopy when only a 3' depth to the center of the tree is in the spray pattern.

Smaller and therefore cheaper equipment:

Small tractors, small sprayers, and other smaller equipment allow narrower alleyways to give higher density tree populations. The alleyway only needs to be the width of a bin. In addition, the smaller equipment causes less soil compaction.

Easier to harvest:

Fruit produced on small trees with only 3' to the center of the trees is easier to harvest. The world record for picking apples, 360 bushels in an 8 hour day, was set in a high density small tree orchard.

Higher water use efficiency:

The energy requirement for moving sap, metabolites, sugar, and secondary plant constituents around in the small tree is lower than in a large tree. The shorter the distance from the root to the shoot or the photosynthesizing shoot to the fruit-producing spur, the less expense there is involved in transport.

NEGATIVE CHARACTERISTICS OF SMALL TREES:

Higher establishment costs:

Cost of trees for the high-density orchard can be intimidating. A high-density orchard of 1,000 trees per acre would cost \$6,000 if the cost per tree is \$6. The advantage of branched trees from the nursery amounts to a year in the orchard, therefore, the additional cost will return more than expended in just a few years. This is a case of having to spend money to make money.

Higher training costs:

Slender spindle, HYTEC, vertical axe, staked or trellised trees require additional grower care per tree to achieve the goal of early foliation and high yields. Time spent in staking and trellising and training trees to control growth and production is required to make the small tree, high-density orchard successful.

Irrigation systems may be more expensive:

Under-tree irrigation lines with more sprinkler heads for adequate water distribution may be required for the high density planting. If overhead sprinkling is used, costs should be about the same.

Higher freeze risk in radiation freezes:

The smaller, shorter tree is at a disadvantage when radiation freezes occur. Protective measures will be required more frequently than with larger trees.

Movement in the orchard is restricted:

Hedgerows of slender spindle, vertical axe, or other high-density system orchards do not allow cross-row traffic. The orchard row middle should be just wide enough for a bin of fruit. Tractor shields and occasional pruning for alley-way width may be required.

More care is required:

Training is required for each tree and each limb of each tree in the high-density orchard. Limb positioning with spreaders or twine hold-downs takes material and time. Stake and trellising operations and maintenance are often necessary.

The advantages of high-density well-trained trees cannot be overcome with greater acreage of larger trees. If a grower cannot produce significant quantities of fruit per acre on efficient, small trees, his income will not be as great as the income of those who do.

—Schuyler Seeley

Benefits of Ground Covers in Orchards:

1. Ground covers replenish organic matter in the soil. This is extremely important since organic matter breaks down to humus that is primarily responsible for soil particle aggregation.
2. Ground covers that maintain soil aggregates allow for much better water penetration into the soil. Cultivation tends to destroy soil aggregates and soil structure resulting in increased soil compaction and poor water availability to the trees.
3. Humus from organic matter also serves to form ion exchange sites for fertilizer elements in the soil so that soils high in humus can hold fertilizers better and help avoid deep percolation of fertilizers that will allow them to enter ground water.
4. Ground covers allow much easier, and usually earlier, movement in the orchard. All tasks that demand travel through the tree rows are facilitated by a good ground cover.

5. Proper selection of ground covers can result in insect control. For instance, grasses used as ground cover do not serve to harbor some detrimental insects that will occupy native weed cover crops.
6. Ground covers in orchards on sloping ground will hold the soil in place and prevent erosion.
7. Ground covers cushion soil and prevent compaction by equipment.
8. A good grass ground cover allows spraying to control broad-leaved weeds such as dandelions that may serve as attractive alternate targets for honeybees during pollination season.
9. Ground covers produce a cooler midsummer environment.
10. Ground covers save equipment wear and tear, especially on rocky sites.
11. Ground covers help break down rocks, gravel, and large sand particles via microbial action fostered by humus, and result in faster soil production than clean-cultivated land.
12. Ground covers keep your machinery, tools, and shoes clean.

— Schuyler Seeley

HONEYBEES IN THE ORCHARD

1. Bees fly into the wind until winds reach » 6 mph. Therefore, place hives on the lee side of the block of trees you want pollinated. Bees tend to fly into the wind when empty and like to coast home on the wind when they return with nectar and pollen.
2. Bees fly when temperatures are above 10 C (50 F) but are much more active at 15 C (60 F) and higher. To help bees fly, do things to heat the hives up. Black energy collecting coatings or coverings, which do not hold water in, on the hives will help in the spring, but not during the hotter summer days. Elevate the hives on a couple of bins so that the hive is above ground level where the temperatures are lower than at 8 to 10 feet. Turn the hives to face the morning sun so that the front of the hive will absorb energy and warm faster. Place 8 to 12 hives together so that they can help keep each other warm.
3. Bees fly in clear weather. They use the sun to navigate. When the weather is cloudy and there is a threat of precipitation, bees, generally, stay in the hive.
4. Bees tend to harvest the sweetest nectar. Often the sweetest nectar is in the flowers on the ground cover in the orchard or on alternate targets outside the orchard. When a worker bee finds a sweet sugar source they harvest a load and return to the hive. When in the hive, they do a dance to show other worker bees the direction and distance to the source of

the nectar. To avoid having bees harvest from the cover crop, if it contains appreciable numbers of plants like dandelions, spray or disk the alternate nectar source before placing the bees in the orchard.

5. Bees tend to stay with a source of nectar once they start on it. If they start on a row of trees, they return again and again. They tend to work one hedgerow of trees and do not fly across the row-middle to another row, but fly down the row. Therefore, the source of pollen, the pollinizer tree, needs to be in the hedgerow.

6. Bees should be placed in the orchard when about 30 % of the fruit flowers are open. They should be removed after bloom before any detrimental sprays are applied.

7. The honey bee is subject to two mites. The Verroa mite that attaches to the skin of the bee and becomes parasitic, and the tracheal mite that enters the bee's trachea and lives there. The tracheal mite may colonize the trachea in numbers sufficient to suffocate the bee. Some strains of bees are more resistant to these mites. In some areas honeybee mortality has reached 80% due to mites and weather problems. The blue orchard bee is not subject to mite attack.

8. Honeybees are colony insects. This makes it easy to handle them. Other bees, like the blue orchard bee, are solitary insects, but they may nest gregariously. They can be handled so that they do a good job in the orchard.



Honey bee on apple flower

THE BLUE ORCHARD BEE

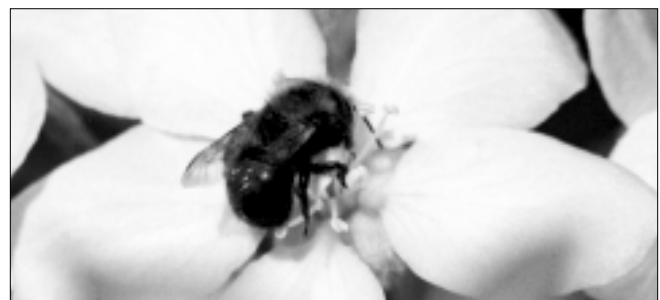
The blue orchard bee is one of about 3,500 species of native bees. They do not produce wax or honey. "In 1985, a 3.5 acre cherry orchard in North Ogden, Utah that in previous years had been pollinated with honey bees at a rate of 2.5 hives per acre, was pollinated with blue orchard bees for the first time. The USDA-ARS Logan Bee Lab staff managed the release of the blue orchard population (2,600 females and 5,200 males) and monitored its emergence and nesting activity. Harvest and yield quantification were conducted by the orchardist. As many as 14,132 female and 19,391

male blue orchard bees were recovered after petal fall. At current prices, and after removing the initial investment bees, the blue orchard bee return obtained amounts of \$12,825 on the open market. The 1998 cherry yield was 32,800 lb., which is twice higher than the best yield in that orchard in the last 20 years (16,000 lb.) and 94% of the cherries made perfect grade (Bosch, Gras Jordi and Kemp, William P. 1998. Exceptional Cherry Production In An Orchard Pollinated with Blue Orchard Bees. TEKTRAN. United States Department of Agriculture – Agricultural Research Service)."

"Blue orchard bees are extremely efficient pollinators of orchard fruits. For example, an individual blue orchard bee can set in excess of 2000 apples per day; by comparison, an individual honeybee on average sets only about 30 per day. This difference occurs because individual orchard bees work faster than honeybees, stay within the orchard (forage range 100 M), contact stigmas consistently and usually prefer orchard bloom to others (Welland, Rex and Duncan, Bob. 1998. Superefficient Pollinator of Orchard Crops. BC Fruit Testers Association.)."

"The blue orchard bee is a pollinator of many fruit crops, including almond, apple, cherry, pear, and plum. One only needs 250-750 orchard mason bees to pollinate an acre of apples. It would take 60,000-120,000 honeybees to cover the same area (Greer, Lane. 1998. Alternative Pollinators: Native Bees. Horticultural Technical Note. Appropriate Technology Transfer for Rural Areas (ATTRA))."

A nesting block for blue orchard bees can be made from a 4" x 4" or 6" x 6" block of wood. Drill 5/16" (8 mm) holes through the block about 1/2" apart. Mount the block on a 1" x 4" or 1" x 6" board so that the holes are covered on one end. Nesting blocks need to be covered with a roof overhang or other shelter for shade and precipitation protection. Place the blocks five to eight feet above soil level with the blocks facing east to south-east. Blocks need to be located near a mud supply – a ditch, canal, or river – since the bees use mud to encapsulate and protect their potential offspring. Nests can be made of PVC pipe and soda straws, plastic, glass tubes or cardboard. Nests need to be brought into storage during the winter and held in a cool place or in refrigeration at 35 to 40 F. As bloom develops in the orchard, bee blocks are placed in the orchard about 3 days before emergence is needed.



Blue Orchard bee on apple flower

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