

The optimum temperature of 95 degrees F would be used as the high temperature for the day when calculating the average temperature for that day.

Biologicals

There are a number of natural products and biological control agents that can be used to manage insect pests of small fruit. Biological pesticides (bio-rational pesticides) are formulated products that use toxins produced by plants (such as rotenone, pyrethrum, sabadilla, ryania, and azadirachtin), or by microorganisms (bacteria, fungi, and viruses).

Rotenone is extracted from the roots of leguminous plants in the genera *Derris* spp. (Far East), or *Lonchocarpus* spp. (Amazon basin, South America). Indigenous people use crude extracts that contain rotenone to kill fish in streams and lakes for harvest, so be careful when using this material around fish bearing waters. *Pyrethrum* is extracted from the flowers of *Chrysanthemum coccineum* and *C. carneum*.

The primary source of pyrethrum today is Kenya. Pyrethrum is a complex of chemicals that attack the peripheral nervous system, and for this reason it is quick acting. *Sabadilla* is extracted from the seeds of the lily-like *Schoenocaulon officinale* plant from Venezuela. The principal ingredients of sabadilla are two alkaloids, cevadine and veratridine.

Ryania is extracted from ground stemwood of *Ryania speciosa*. These botanical insecticides have broad-spectral activity, and are harmful to insect pests and their natural enemies, while azadirachtin is toxic to insect pests and relatively nontoxic to biological control agents. **Azadirachtin** is one of a complex of chemicals (over 20 active ingredients) extracted from the foliage and seeds of the neem tree (*Azadirachta indica*).

There are different strains of *Bacillus thuringiensis* that produce different Cry toxins. These toxins must be ingested to be effective, and are most effective against small larvae, and for this reason timing of applications is critical. Toxins from *B.t. aizawai* (Cry 1C) and *B.t. kurstaki* (Cry 1Aa, 1Ab, & 1Ac) are toxic to Lepidoptera larvae (caterpillars), while the *B.t. tenebrionis* (Cry 3A) toxin is specific to Colorado potato beetle larvae, and a few other leaf feeding beetles that attack trees. Formulated products may contain toxins from one or more strains of Bt. There are other products derived from toxins produced by microorganisms.

Spinosyns are a naturally derived group of chemicals produced by an Actinomycete fungus, *Saccharopolyspora spinosa*, and formulated as **SpinTor**. This product is very effective against a wide range of insect pests, yet relatively harmless to natural enemies. Avermectin B1a (80%) and B1b (20%) are formulated as **Agri-Mek**. The avermectins are derived from another Actinomycete fungus, *Streptomyces avermitilis*. Agri-Mek is very effective against spider mites, and relatively harmless against natural enemies.

Several bio-rational products have been developed by reacting oleic acid with potassium hydroxide to produce potassium oleate, or soap. Potassium oleate used to be available as "Castile Soap." This soap was made from olive oil, while the insecticidal soaps are made from oleic acid extracted from animal fat. The insecticide product is **Safer's Soap**, and the herbicide is **Scythe**.

Natural Enemies and Predators

There are a wide range of insect natural enemies, such as other insects, nematodes, fungi, and viruses that can be used to control insect pests of small fruits. Many of these biological control agents are mass-produced and available for purchase. The cost-effectiveness of using biological control agents varies significantly from one situation to another. Often, inundative releases of purchased organisms are quite expensive and may not "pay-off" if another alternative is available. It is best to take advantage of existing populations of natural enemies and to engage in practices that protect these agents. To this end, it is important to use "soft insecticides," i.e. insecticides that are toxic to the target pest, but relatively nontoxic to natural enemies, or to use other practices that disrupt the pest's biology, such

Warning! Pesticides are poisonous. Read and follow all directions and safety precautions on labels. Handle carefully and store in original labeled containers out of reach of children, pets and livestock. Dispose of empty containers immediately in a safe manner and place. Contact your state Department of Agriculture for current regulations.