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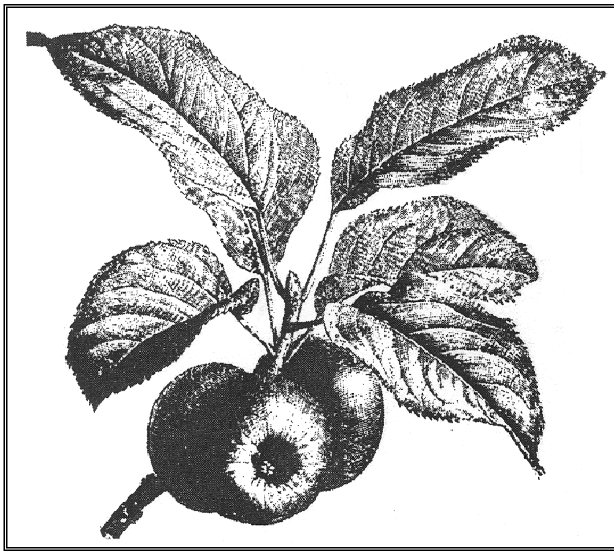
ORGANIC AND LOW-SPRAY APPLE PRODUCTION

HORTICULTURE PRODUCTION GUIDE

Abstract: *This publication surveys information appropriate to organic and low-spray apple production, drawing on recent research and producer experience. Many aspects of apple production will be the same whether the grower uses low-spray, organic or conventional management. Accordingly, this publication focuses on the aspects that differ from conventional practice—primarily pest and disease control. (Information on organic weed control and fertility management is presented in a separate ATTRA publication, Overview of Organic Fruit Production.) The major insect pests and diseases are covered, and the most effective low-spray and organic control methods are introduced. Also included are three profiles of working orchards, and a section dealing with economic considerations. There are four appendices: a list of resources for information and supplies, a chart of disease-resistant apple varieties, an article explaining the use of degree days in codling moth management, and a profile of a successful low-spray program.*

By Richard Earles, Guy Ames, Radhika Balasubrahmanyam, and Holly Born, NCAT Agriculture Specialists
October 1999



INTRODUCTION

At least two key insect pests, several serious diseases, and high cosmetic standards for fresh market fruit present formidable obstacles to organic or low-spray apple production. Moreover, recent "food scares" involving apple juice, and subsequent regulatory actions, threaten an important value-added component of low-spray and organic operations, which often have a relatively high percent of juice apples. Nevertheless, with disease-resistant cultivars and careful management, growers can greatly reduce—and in some cases eliminate—their reliance on synthetic pesticides.

As this publication is written for national distribution, it can only introduce the most common pest and disease problems and point toward some alternative control strategies that have been effective. Not all of these methods will be appropriate for every orchard or every region. In other words, the following is a set of guidelines, not a list of prescriptions. Geographical/climatic considerations, cultivar selection, the local pest complex, market prices, production costs, and other factors will all influence the design and viability of a commercial organic or low-spray system. Reducing chemical input and foregoing conventional calendar spray schedules will require the orchardist to develop an understanding of the orchard agro-ecosystem. In this regard, there is no substitute for direct observation and experience, along with a willingness to experiment.

Contents:

A note on terms:

The term **low-spray** has no precise definition and simply refers to a reduced synthetic pesticide spray program *relative* to an area's prevailing or conventional spray programs. The word **organic** has precise legal definitions in many states, and certification groups maintain standards for what can be marketed as "organically grown." The USDA is currently attempting to implement a national set of standards. Refer to the ATTRA publication *Organic Certification* for an in-depth discussion of this topic. In general, it can be said that "organic" refers to growing methods that utilize only naturally occurring substances or organisms for fertility management and pest and disease control.

Low-spray and organic apple production systems are information-dependent, and the orchardist should not underestimate the value of keeping up with research in this rapidly changing field. Internationally, researchers and producers are working to craft and implement advanced Integrated Pest Management (IPM) programs that use a minimum of synthetic chemicals, seek least-toxic alternatives, and utilize biological and cultural controls. The ATTRA publication *Integrated Pest Management* provides a good introduction to IPM principles and practices. For an overview of the history and current state of IPM disease management in apples, and an example of an advanced IPM program that reduced fungicide use by 34% while retaining conventional levels of disease control, see the academic article cited as reference (1).

A well laid-out young orchard, Pacific Northwest

What may begin as a fragmented, pest-by-pest set of tactics should gradually be integrated into an overall management plan in which the various strategies work together as much as possible. Obstacles to a holistic or integrated approach include the following:

- Cultural guidelines for controlling one pest may create conditions that favor another pest;
- Many ecological pest control tactics tend to give highly variable results from location to location and year to year;
- Traditional local support services are often unable to provide much information or guidance;
- Available ecological practices may be labor- and/or capital-intensive. (2).

GEOGRAPHICAL FACTORS AFFECTING DISEASE AND PEST INCIDENCE

West of the "tree line" (approximately the 97th meridian; a line roughly running from Ft. Worth, TX, to Fargo, ND), a major pest of many tree fruits—the plum curculio—is not present. This fact, coupled with reduced disease pressure, facilitates the organic production of apples in much of the West.

Eastern growers must contend with the plum curculio and increased incidence of fungal diseases. Northeastern growers have the apple maggot as an additional major pest. In the Southeast, fruit rots can be especially troublesome. Commercial-scale organic production of apples in the East is very problematic, mostly due to the presence of the plum curculio. Organic growers should plan for no more than 60–70% fresh market fruit from any harvest. The remainder will have to be culled for processing or discarded. Research and experience indicate that without some form of insect control more than 90% of an apple crop will suffer insect damage (3).

Eastern commercial-scale growers seeking to reduce pesticide sprays should study the article "Very Low-Spray Apple Growing," included as

Appendix 4. Some Eastern growers using the approach outlined in that article have reduced their synthetic pesticide treatments to two insecticide sprays for the curculio and achieved 90% or better fresh-market quality fruit.

Farmer profile:
Steven Clarke, Milton, New York

If Steven Clarke were asked to name the three factors absolutely vital to the success of an IPM-based orchard, he would say, "Timing, timing, timing." Clarke, who runs Prospect Hill Orchards in New York's Hudson Valley with his wife Judy, their daughter Pam and son Brad, has been in the fruit business for 30 years. The family farm was started in 1817 by Steve's great-great-great-grandfather. Ten years ago they made the switch to IPM, and their apples, now marketed through local fruit stands and a U-Pick, and at farmers' markets in New York City, bear the CORE Values Northeast seal, a regional eco-label that guarantees the fruit has been raised using ecologically responsible IPM methods.

The shift to IPM has meant a reduction in pesticide use and a perceptible increase in beneficial insect populations in the orchard—more syrphid flies, more ladybugs, fewer aphids. Judy says that they've also observed more fly speck and sooty blotch, diseases that scar the fruit surface but do no harm to the fruit. She attributes the incidence of these diseases to the minimal spray program used on the farm, adding that the blemishes can sometimes constitute a marketing challenge. "Consumers are generally willing to tolerate a certain number of marks on the fruit," she says, "We do some general education. Some people walk away when they hear that the apples are not organic, but the majority of people stop to listen."

The Clarkes raise 25 varieties of apples, including Red and Golden Delicious, Macintosh, Empire, Mutsu, Rome, McCoun and Gala. Ninety percent of the crop is picked into 20-bushel bins and sold wholesale to local fruit stands. The rest is sold by Pam at open-air farmers' markets in New York city or by Judy through the U-pick. A small part of the crop is processed into jam or dried and packed into 1- or 5-ounce bags for sale. "We don't receive a premium, at least not as yet," says Judy, "but we do make a profit."

Apple scab, their most serious disease problem, is controlled by carefully timed applications of EBDC (ethylene bisdithiocarbamate) contact fungicides like Mancozeb, Penncozeb and Polyram. EBDC fungicides offer broad spectrum control and are used mainly for foliar disease management. "We may spray the same number of times as conventional growers," says Steve, "but we use half the amount they do." Following late winter pruning, he runs through the orchard with a sweeper, gathering the brush and the leaves and grinding them up with a hammer knife mower. The chipping and grinding shatter the leaves and help to reduce the overwintering inoculum in spring.

Powdery mildew, which sets in right after bloom, is usually controlled by three applications of Bayleton at the rate of 2 oz/acre. This year, Clarke plans to switch to sulfur, a less expensive option. Quince rust and apple cedar rust are two other fungal diseases that occur between pink and one week after petal fall. Both are well controlled by the EBDC's and are not a problem, says Clarke.

Abandoned orchards in the surrounding area are a persistent source of insect pests. Plum curculio activity is triggered by the first warm night of the season after bloom, Clarke observes, when it begins its migration into his orchard. At this time, he sprays the edge of the orchard with Guthion. Ten days later, he follows this up with an orchard-wide spray. If this is followed by cool weather, which the curculio likes, he may have to spray the border once more.

Red sticky spheres (see section on apple maggots below) serve to signal the emergence of adult apple maggot flies. To control the flies Clarke uses a single spray around the time of emergence, usually after the 4th of July. Late-yielding varieties may get another pesticide application later in the season. Predatory mites *(T. pyri)* released in the orchard control red mites. Dormant oil helps to destroy red mite eggs and, if applied early enough, also controls San Jose scale.

The oblique banded leafroller, a particularly persistent pest, takes "a lot of scouting" and well-timed sprays of Bt, sometimes Lorsban, to control.

Clarke uses no compost but makes supplemental, precision applications of potash and nitrogen. Round Up™ is the preferred option for weed control because it is a contact herbicide and leaves no residue. Foliar applications of micronutrients such as zinc and boron at pink, and calcium and magnesium during the growing season, have improved yields. Annual output averages 35,000 bushels, with 80 acres in production at any given time. As an experiment, Clarke plans to set aside five acres of trees for organic production. Here, he will use disease-resistant varieties and organic techniques to mitigate insect and disease pressure.

For information, contact Steven, Pam and Judy Clarke, Prospect Hill Orchards, 40 Clarke's Lane, Milton NY. Phone: 914-795-2383. E-mail: apelsteve@hvi.net

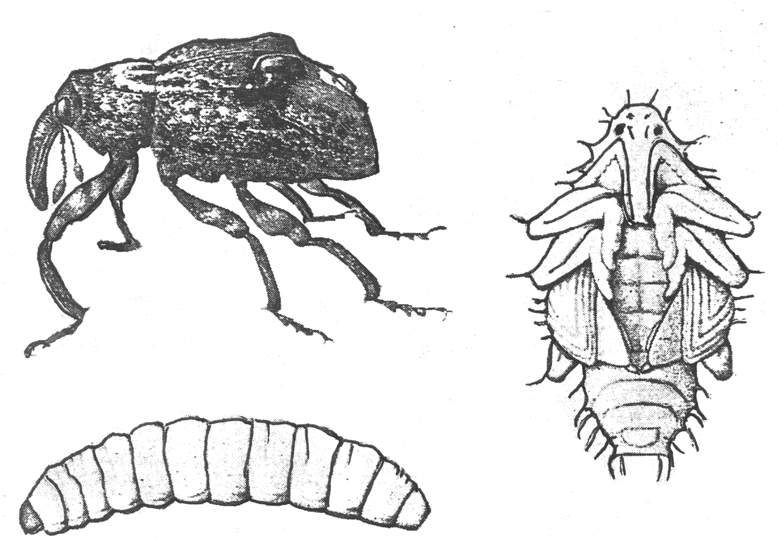
INSECT AND MITE PESTS

Plum curculio

> "It is the considered opinion of entomologists that plum curculios, not gravity, cause apples to fall."—May Berenbaum (4)
>
> "It has been written that there are no organic eating apples (as opposed to juice/vinegar apples) grown in Massachusetts, and that this pest is the barrier preventing such in the Northeast."—Ralph DeGregorio (5)

The plum curculio (*Contrachelus nenuphar*), a small brownish weevil, has been the Achilles heel of organic apple production in the eastern U.S.. This species of snout beetle injures fruit in several ways:

- Scarring from surface feeding and oviposition (egg depositing);
- Internal damage from burrowing larvae;
- Premature fruit drop ("June drops");



The plum curculio, *Conotrachelus nenuphar*. Adult above at left; larva below at left; pupa at right, ventral view. About 8 times natural size. (*From Ill. Natural History Survey.)*

- Puncturing by adults feeding in late summer and fall.

The adult weevils overwinter in woodlots, fence rows, and hedges, and move into the orchard during bloom to feed on young flowers. After mating, the female bores a small hole in the skin of a developing fruit, deposits a single egg, and then makes a crescent cut below the hole to protect the egg from being crushed by the rapidly expanding fruit tissue. The female lays an average of 150 to 200 eggs, which hatch 2 to 12 days later. The grub tunnels into the fruit's central seed cavity where it feeds until it has completed its development—about three weeks. Then it generates and releases pectin enzymes that "trick" the host fruit into dropping prematurely, eats its way out of the fallen fruit, and enters the soil to pupate (4).

Biological monitoring—systematically scouting the orchard to detect the presence or measure the population density of pests—provides critical information for choosing and timing control strategies. Monitoring is more difficult and more labor-intensive for the plum curculio than for other insects. USDA Agricultural Research Service (ARS) scientists have patented a pheromone trap that can capture the insects as

Table 1: **Detecting Plum Curculio in the Orchard (7)**

STAGE	TIMING	WHERE TO LOOK
Adults	Spring when temperatures exceed 60°F (15.5°C)	In orchard adjacent to hedgerow. Feeding wounds are frequently the first sign of adult presence.
Adults	Late July to hibernation (temps. Below 60°F (15.5°C)	Same as above
Eggs	Petal fall and 30 days thereafter	On developing fruit within crescent shaped oviposition wounds
Larvae	Early June through mid-July	Within injured, dropped fruit.
Pupae	Mid-July through mid-August	In soil within 25mm (1 in.) of surface

they first arrive in the orchard, giving the grower an early warning. Until this technology is available commercially, visual observation of adults and their crescent-shaped oviposition marks remains the best mode of detection. Since the PC enters the orchard from surrounding habitat such as woodlots, it is important to check the fruit on perimeter apple trees at bloom. Plum trees planted as "trap trees" could serve as early detectors, since the crescent signature appears earlier on the plum fruit than on the apple (6). According to Dr. Ron Prokopy (8), anentomologist at the University of Massachusetts and a small-scale commercial orchardist, an effective, organically acceptable control for the plum curculio does not exist (though a revolutionary non-synthetic spray may well change that. See **Kaolin clay**, below.) Prokopy has achieved control with 2–3 sprays (the first at petal fall and the remainder at 10–14 day intervals) of the synthetic pesticide Imidan™.

Unlike many synthetic materials, Imidan has a short residual effect and a relatively low acute toxicity. If Prokopy does not spray, 80–90% of his fruit suffer at least some PC damage. Imidan is not allowable in organic production. See Appendix 4 for more detailed information on Prokopy's low-spray program.

A 5% formulation of rotenone provides some control; however, coverage must be very thorough, and applications made at roughly weekly intervals for a total of 12–15 treatments to keep crop damage under 25% (9). While such a program is technically "organic," frequent treatments with rotenone are detrimental to beneficial insects and other non-target organisms. In fact, most certification programs restrict or prohibit the use of rotenone in organic production because it is a broad-spectrum pesticide.

A combination of several cultural control methods can be helpful against the plum curculio; however, none provides a level of control comparable to that achieved with chemicals. Since fruit infested with PC larvae typically drop before the larvae complete their feeding, prompt gathering and disposal of the "drops"—before the larvae leave them to enter the soil—reduces the number of first generation adults. The infested drops should be carefully destroyed by boiling, burning, or soaking in oil. The drops on the two or three outside rows of the orchard are likely to be more heavily infested than those further in the orchard. Sometimes the fruit that drops in May or June contains very few PC larvae. In such cases the early dropping may

— The plum curculio: Adult female on plum, showing the circular feeding punctures and the crescentric egg-laying punctures. Enlarged. (USDA)

Orchard establishment

"Because of plum curculio's preference for maple woodlots as overwintering sites and its low winter survival in other locations, it seems advisable to establish orchards as far removed as possible from maple woodlots. Furthermore, because plum curculio also attacks crabapple, wild apples, pears, plums, cherries, peach, apricot, quince, and hawthorn, apple orchards should be kept away from these trees, and wild host trees should be removed from the surrounding area.

"A stone mulch about 1 foot in radius around the tree trunk with a thick spoiled hay mulch out of the dripline is likely to encourage many predators of plum curculio. Efficient mice guards must be used in conjunction with mulches.

"A diverse array of ground vegetation with small flowers is likely to attract parasitic wasps, which may parasitize not only plum curculio but also many other pests. This would need to be mown during apple blossom to avoid attracting the bees away from the apple pollination. Bare soil in the orchard is probably also unattractive to plum curculio, but its dependence on heavy herbicide use and associated soil erosion makes it an unsuitable solution.

"Sites adjacent to maple woodlots could be made less attractive by planting one or two rows of conifers along the edge to discourage plum curculios from entering the woodlot in the fall. Coniferous leaf litter scattered along the woodlot edge might also repel the plum curculio."
—Dr. Stuart B. Hill (6)

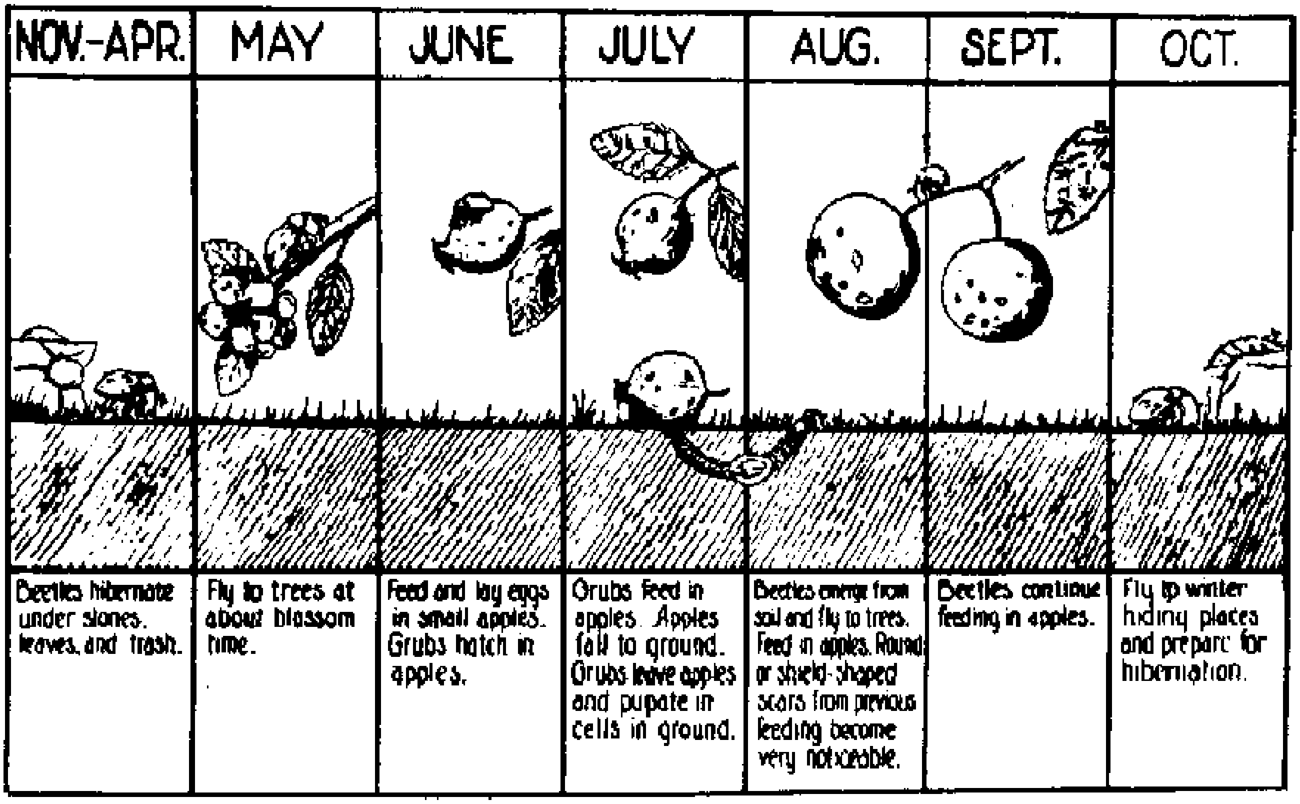
be attributable to heavy fruit set, poor pollination, or both (9).

The adults may be knocked from trees by jarring the limbs with a padded board. They "play possum" when thus disturbed, and will drop from the tree to a tarp or sheet placed below. Adult curculio beetles caught in this manner can be crushed or dropped into a can of kerosene. Tree jarring should be done early in the morning, while it is still cool, or the beetles will fly away. For significant control to be achieved by this method, trees must be jarred and beetles destroyed every morning for 4–6 weeks, beginning at pink. Growers who have used this or similar methods have reported no better than around 50% control (10, 11). Because of the labor intensity and less-than- commercial levels of control, tree jarring is most commonly used to monitor for the presence of adult beetles rather than for control.

Disking during the pupal period ("cocoon stage") is a method of mechanical control. The pupa of the plum curculio is very fragile. If its cocoon is disturbed, the pupa fails to transform into an adult. Pupation usually occurs within the upper inch of soil. The most desirable time to begin cultivation for destruction of pupae appears to be about three weeks after the infested fruit starts to drop from the trees. Cultivation should be continued at weekly intervals for a period of several weeks. Cultivation before the curculios pupate is of little value. If the cocoon is broken before pupation occurs, another cocoon is made by the larva.

Covering the drops with soil before the larvae emerge from them is undesirable since it protects the larvae from drying. Research done in the 50's in Arkansas indicated that cultivation can provide significant PC control (12); however, long-term reliance on this method could result in erosion and depletion of soil organic matter.

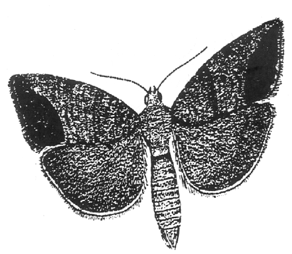
Free-ranging fowl such as chickens, ducks, and geese can be encouraged to scratch for the larvae and adult weevils by mixing poultry feed into the soil under the trees. Or the fowl could be moved along the edge of the orchard in mobile chicken coops. Dr. Stuart Hill, an entomologist formerly at McGill University, has written that every



Seasonal history of plum curculio (USDA)

successful organic orchard he's visited "had several hundred chickens in them as pest control agents" (6).

Codling moth



Codling Moth

The codling moth, *Cydia pomonella*, is present throughout North American apple growing regions. Prior to the advent of synthetic pesticides, the codling moth larva was the proverbial "worm in the apple." Relatively cold regions may have only one generation of the codling moth, while in the warmest apple growing areas the codling moth may pass through 2 to 3 generations per season. Growers who spray Imidan™ for the plum curculio will find that these sprays also take care of most of the codling moths.Several organically acceptable controls are available and discussed below. Also see the section on **kaolin clay**.

Among the most promising non-toxic controls for codling moth is mating disruption using pheromones—chemicals naturally produced by insects as a means of communication. During the mating period, female codling moths release pheromones that signal their location to males. By releasing quantities of these pheromones into the orchard, the grower can confuse and disrupt the moth's mating cycle.

This approach faces two general problems—difficulties with sustaining an even, long-lasting distribution of pheromones throughout the orchard, and complications due to the biology and initial distribution of the codling moth. For instance, dispensers can release pheromones too slowly or too quickly, thus allowing mating to occur. Orchard layout is another consideration. For best results, trees should be evenly spaced and of equal heights, since treeless spaces and taller trees interrupt the pheromone spread. Cold weather can cause too little pheromone release and hot weather can cause too fast a depletion. Since the pheromones actually attract male moths, fruit damage can be

worse if pheromone levels drop low enough to allow mating to occur (13).
Dispensers should be placed as high in the trees as possible, since mating can occur in the air above the dispensers. For pheromone dispensers to be effective, it is important to use them at the recommended rate per acre (14). One improvement currently being tested is an aerosol dispenser, nicknamed the "puffer," which uses a timer to periodically spray pheromone into the orchard air. These puffers could overcome some of the problems mentioned above and reduce the labor requirement of tying the pheromone twist-ties onto orchard trees (15).

When codling moth populations are high, pheromones may need to be used in combination with an insecticide spray (16). For organic growers it will probably not be feasible to achieve adequate suppression using mating disruption alone. Growers in California have significantly improved codling moth control by combining mating disruption with black light traps. Both male and female codling moths are strongly attracted to black light (17). These traps are available from Superior Ag Products (see Appendix 1).

Prior to the development of the mating disruption system, pheromones were used primarily for monitoring to determine the best timing for spray applications. Appendix 3 details the monitoring tools available for detecting this pest by using "degree days". Since insects are cold blooded, their physical development progresses according to the temperatures to which they are exposed. Once the developmental rate of a species at certain temperatures has been determined, weather monitoring can forecast when an event, such as egg hatch, will occur. This information can be used to implement control methods, such as pesticide applications or cultural manipulations, so that they are used at the most effective time in the pest's life cycle. There are several "windows" in the pest's development that, if detected, can greatly increase the effectiveness of control measures. Determination of these critical periods is especially important, since codling moth eggs are fairly resistant to chemical treatments, and once the eggs hatch, the larvae will quickly enter a fruit and again be protected from sprays.

A new product formulated to attract and kill the codling moth, Last Call™, is a combination of a pheromone and the insecticide permethrin. Its success is not as sensitive to the variables in land, wind, and canopy that make mating disruption tricky. The use of the insecticide is appropriate for low-spray programs, as the pheromone makes the insecticide more selective (better-targeted at the pest.) Last Call has a 28–42 day field life, is insoluble in water, and does not harm beneficials (18). For more information on Last Call contact IPM Technologies (see Appendix 1).

Bacillus thuringiensis (Bt), a naturally occurring bacterium, can be used in organic production of apples against the codling moth, but with limited results. Other lepidopterous (worm) pests, such as leafrollers, are much more susceptible to the bacteria (19). Products formulated from this microorganism include Dipel, Javelin™, and Thuricide™. New formulations with longer field life may be more effective against the codling moth; however, since some of these are the result of genetic engineering, organic growers may need to contact their certifying organizations to check on acceptability.

The trichogramma wasp is increasingly used in U.S. orchards as a biological control organism against codling moth. The wasps can be ordered from insectaries, which ship them as pupae inside parasitized grain moth eggs glued to perforated cards (100,000 trichogramma per card). Each card can be broken into 30 squares, allowing for even distribution in orchards and fields. Trichogramma parasitize freshly deposited moth eggs, so release of the adult wasps should be timed to coincide with moth egg-laying (see Appendix 3). The adult trichogramma feed on insect eggs, nectar, pollen, and honeydew. They live much longer and destroy more codling moths when supplied with nectar. Good nectar and pollen sources in and around the orchard, such as borders or strips of unsprayed alfalfa, sorghum, sunflower, corn, clovers, and wildflowers, will increase trichogramma parasitism of pest eggs. Beneficial organisms are not sufficient by

ATTRACTING AND CONSERVING BENEFICIAL INSECTS

"Farmscaping" is the use of hedgerows, insectary plants, cover crops, and water reservoirs to attract and support populations of "beneficial" organisms—natural predators of crop pests. Because of the inherent ecological stability of a permanent planting of trees, apple orchards are generally more amenable to farmscaping than annual cropping systems.

Farmscaping concepts can be used to design an agro-ecosystem that increases plant diversity, confuses pest insects, and disrupts pest life cycles. The goal is to create a more species-diverse environment by providing a variety of habitats (niches) for organisms to exploit. Farmscaping practices will not eliminate pest problems, but they can help reduce pest pressure and, when integrated with cultural control methods, contribute to minimizing the use of chemicals. However, simply using a random selection of flowering plants for farmscaping may favor pest populations over beneficial organisms, so it is important to include only those plants (and planting situations) that best support populations of beneficial organisms.

Ron Prokopy (8, 22) has written about the management dilemma faced by some farmers in trying to implement farmscaping concepts: how to manage a resource that has both positive and negative impacts on crop yield and/or health. To illustrate, Prokopy notes that the presence of brambles in an apple orchard supports significant populations of phytoseiid predatory mites. However, brambles are important hosts of two major summer diseases of pome fruit—sooty blotch and flyspeck. Should the farmer retain the brambles and ensure the positive effect of the mites, or reduce disease pressure by eliminating them? This is a good example of the quandaries presented by ecological pest management.

Flowering plants provide various forms of food to beneficials, including nectar, pollen, honeydew (from aphids on plants), and herbivorous insects and mites. A mix of plants such as dill, hairy vetch, spearmint, Queen Anne's lace, buckwheat, yarrow, white clover, tansy, cowpea, and cosmos will attract and conserve many beneficials, including trichogramma wasps. It may not be necessary to sow flowers or put much time into planning to take advantage of beneficial-sustaining habitat. When low-spray orchardist Guy Ames mows the paths between his apple rows, he simply leaves an un-mown strip down the middle of each path, where weeds such as Queen Anne's lace, clovers, and vetches can go to flower. He has noticed a marked increase in beneficials in the orchard, and enjoys the aesthetic effect of wildflowers blooming among the apple trees.

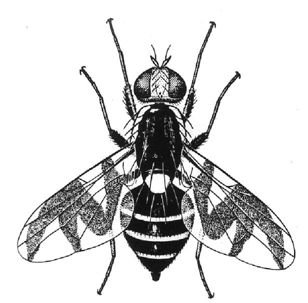
For further information, including resources and seed suppliers, see the ATTRA publication ***Farmscaping to Enhance Biological Control***.

themselves to effect a commercially acceptable level of control; rather they play a potentially potent part in an overall, long-range *ecological* management strategy. Best results are usually observed after three to five years of releases, as the population of beneficials grows. As trichogramma are very sensitive to pesticides, the spraying program should be designed to minimize chemical interference with the biological control cycle (20).

Sanitation and cultural practices can help to reduce codling moth populations. Woodpiles, boxes, and bins can be a major source of reinfestation, so these should be kept away from the orchard. If wooden crates or boxes are discovered to contain codling moth pupal cases, they can be disinfested by scorching with a propane torch.

Codling moth larvae can also be intercepted as they descend the trunk to pupate in bark crevices, soil, and certain weed stems. Wrap the trunks with corrugated cardboard, which will provide an attractive, artificial pupation site. In areas with only one generation of codling moth, remove and burn the cardboard at the end of the season. If there are two or more generations, the cardboard should be removed and destroyed about a month after the first larvae moved down to pupate. To determine the timing of this larval movement use the degree day method described in Appendix 3, or employ a trap of a six-inch-wide burlap strip painted with Tanglefoot™, wrapped around the trunk just above the cardboard wraps (21).

Apple Maggot

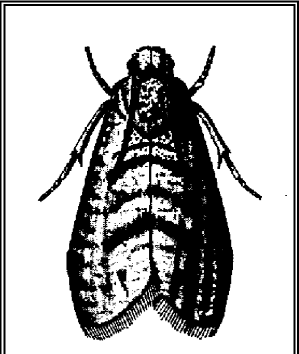

Apple Maggot

Another major apple pest is the apple maggot, *Rhagoletis pomonella*. It is a problem primarily in the Northeast and the upper Midwest. To monitor adult population levels, red spheres covered with a sticky coating and impregnated with a fly-attracting odor are hung in the orchard. If enough spheres are used, the flies can also be mass-trapped. This technique may reduce or eliminate the need for pesticide applications. The spheres are available from several suppliers, including Gempler's, Inc. (see Appendix 1).

Removing hawthorns and abandoned or neglected apple trees near the orchard should help in reducing fly influx into the orchard. The flies are susceptible to pyrethrum, rotenone, and diatomaceous earth. Also, University of Massachusetts research indicates that a Bordeaux spray residue on the apples deters egg-laying by the flies (however, it should be noted that Bordeaux sprays at this time—roughly 30 days from petal fall—could induce leaf burn and russeting of the fruit).

Like the plum curculio and the codling moth, the apple maggot has been suppressed in trials by the **kaolin clay** application discussed below.

Oriental fruit moth


Oriental Fruit Moth

Usually thought of as a pest of stone fruits, this insect has adapted to exploit apples, primarily in the South and upper South. It is a direct pest of the fruit, tunneling randomly throughout the flesh (in contrast to the codling moth, which primarily feeds around the seed cavity). It is relatively easy to control with insecticides, especially if sprays are timed by using commercially available pheromone traps. Unfortunately, due to differing life cycles, the sprays for plum curculio and codling moth do not control the Oriental fruit moth. Sprays for this pest are usually needed later in the season, when they may be disruptive to beneficial insects. A pheromone-based mating disruption system (Isomate-M™) has proved effective and is registered for use on apples.

Minor and induced pests

All of the aforementioned insects are direct pests of the apple fruit. Most of the so-called minor pests —mites, aphids, scale, leafrollers, and others—feed primarily on the stems and foliage. In general, these pests can be tolerated in much higher numbers than the direct fruit pests, but they can occur in high enough numbers to seriously weaken the tree, resulting in reduced quality and quantity of fruit and perhaps tree death.

Many of these minor pests are "induced" pests—that is, they have achieved pest status because pesticides that were targeted for major pests killed beneficial organisms that would otherwise have kept these minor pests below damage thresholds.

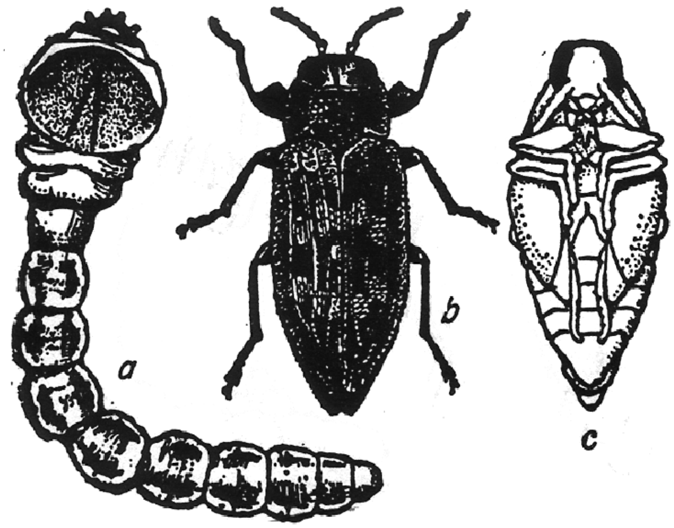
Non-selective pesticides—those that affect beneficial and pest organisms alike—whether organic or synthetic, can cause this phenomenon.

Dr. Ron Prokopy's low-spray system (see Appendix 4) is largely based on the supposition that avoidance of non-selective pesticide use during mid and late season will preserve adequate numbers of beneficial organisms, which will control these minor pests. Interestingly, organic growers who have to rely on frequent sprays of non-selective botanical pesticides (especially rotenone and pyrethrum) may suffer more from induced pest problems than low-spray growers who are able to stop spraying earlier in the season.

There are relatively non-toxic ways to control most of these minor pests, should they become troublesome. *Bacillus thuringiensis* is effective against lepidopteran pests such as leafrollers. Oil sprays (dormant and summer types) are effective against mites, scale, and eggs of some other pests. Oils should not be used in conjunction with or within 30 days of sulfur applications, since a combination of the two can cause phytotoxicity (damage to the plants, in this case leaf "burning"). M-Pede™ insecticidal soap is effective against aphids and mites if coverage is adequate. Beneficial mites, ladybeetles, green lacewings, and parasitoid wasps are also commercially available and can be helpful against many of the minor pests. The **kaolin clay** spray discussed below has been found to control leafhoppers and leafrollers, and to provide significant levels of suppression against mites, apple suckers, stink bugs and thrips.

Borers

Another important production concern for organic or low-spray apple growers is borer control. There are two species of flatheaded borers that may invade apple trees. *Chrysobothris femorata* is the species endemic to the East. On the Pacific coast, *C. mali* fills a similar niche. Adults emerge from woodland trees in late April through early May, and begin laying eggs beneath bark scales on the tree. The graft union is a favorite place for egg deposition. Upon hatching, the larvae burrow under the bark and feed on the cambium—the layer of tissue just underneath the bark. Development is usually completed in one year, but sometimes two years are required.



Flathead apple tree borer *Chrysobothrs femorata*: a. larva; b. adult beetle; c. pupa. *About twice the normal size*. (USDA)

Maintaining trees in good vigor is important first-line protection from flatheaded borers, since a tree in good vigor will be able to drown an invading larva with sap. Drought-stressed trees are much more susceptible to borers; therefore, adequate water is essential.

The roundheaded apple tree borer, *Saperda candida*, attacks the tree near ground level, and is therefore harder to exclude using a wrap or paint. As with the flatheaded borer, keeping the tree in good vigor is the first line of defense. Removing serviceberry trees (*Amelanchier* spp.) in close proximity to the orchard may also help, as the serviceberry is a preferred host for the roundheaded borer.

Another borer exclusive to the East, the dogwood borer or *Synanthedon scitula*, feeds primarily on burr knot tissue on clonal rootstocks. Burr knots are clusters of root initials which develop on the above-ground portion of some rootstocks. Planting so that the graft or bud union is within one inch of the soil should inhibit the development of burr knots, thereby preventing dogwood borer attack. Painting exposed burr knots with interior white latex paint is also helpful. Unless the infestation is heavy, dogwood borer damage is generally not as important as that caused by flatheaded or roundheaded apple tree borers.

For all species of borers, the larvae can be removed from the trunk with a jackknife or piece of wire. Look for signs of borer damage, such as frass mixed with sawdust, at the base of the tree and at the pest's entry hole. Because the roundheaded borer may burrow deep into roots, it is important to check routinely (at least twice during the growing season; e.g., once in May and again in September) for borers, or they can extend beyond the range of manual removal.

Perhaps the best non-chemical protection from all species of borers is to wrap the bottom 12–18 inches of the trunk in window screen (metal, fiberglass, or nylon are all effective). Secure the top with a twist-tie, being certain to loosen and re-tie at least once a year. The bottom should be snug against the ground or also secured with a twist-tie. Painting trunks with interior white latex also helps reduce borer attack.

KAOLIN CLAY

A new particle film spray, marketed under the trademark Surround WP Crop Protectant, may prove to be the key to making organic apple production economically viable in the Eastern U.S. In addition to suppressing plum curculio, Surround™ provides adequate control for *most, if not all other insect pests of apples, with the possible exception of the wooly apple aphid.*

The active ingredient in the product is kaolin clay, an edible mineral long used as an anti-caking agent in processed foods, and in such products as toothpaste and Kaopectate. There appears to be no mammalian toxicity or any danger to the environment posed by the use of kaolin in pest control. Surround has already received EPA registration, and EPA considers the active ingredient GRAS—generally recognized as safe—and thus exempt from requirements of a tolerance for residues.

The spray was developed by Drs. Michael Glenn and Gary Puterka (24) of the USDA/ARS at Kearneysville, WV, in cooperation with the Engelhard Corporation (see Appendix 1), which began marketing the product in 1999 on a limited basis. Surround will be available in 2000 in much of the U.S., and it was listed by The Organic Materials Review Institute for use in organic production on March 7, 2000.

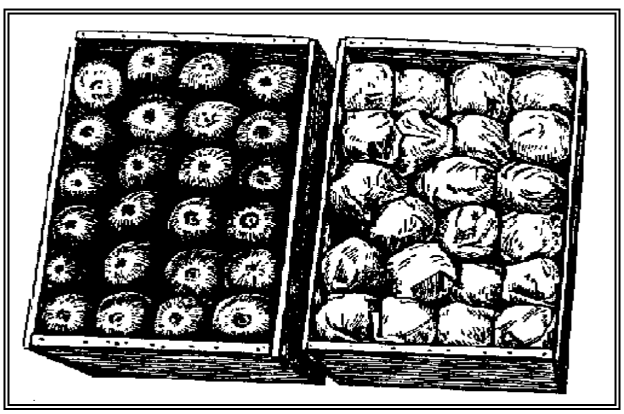
Surround is sprayed on as a liquid, which evaporates, leaving a protective powdery film on the surfaces of leaves, stems, and fruit. Conventional spray equipment can be used, and full coverage is important. The film works to deter insects in several ways. Tiny particles of the clay attach to the insects when they contact the tree, agitating and repelling them. Even if particles don't attach to their bodies, the insects find the coated plant or fruit unsuitable for feeding and egg-laying. In addition, the highly reflective white coating makes the tree unrecognizable as a host (25).

The standard Surround spray program for plum curculio and first-generation codling moth starts at first petal fall and continues for 6 to 8 weekly sprays or until the infestation is over. Discontinuing sprays at this point will leave little or no residue at harvest because of rain and wind attrition. If a full-season program is used to suppress later-season threats such as apple maggot, growers will need to use a scrubber/washer to remove any dust remaining on the fruit for fresh market sales. Although this residue is not considered harmful, it might be considered unsightly by consumers. However, the dust residue is not a problem for processing fruit.

Trial applications of the spray showed that where plum curculio damage was 20–30% in unsprayed checks, the treatments receiving the particle film had only .5–1% damage. Dr. Puterka is careful to say that his trials indicate "suppression" of PC damage rather than complete control, but for the organic grower looking to achieve an economic level of control, the distinction is probably not relevant. What the researcher terms "suppression" in these USDA trials is very close to control, far closer than any other organically suitable option.

Dr. Puterka has speculated that in areas where PC pressure is especially heavy (for instance in unsprayed trees in northwest Arkansas which can suffer up to 90% damage), shortening the recommended spray interval from 7–10 days to every 5 days might provide the levels of suppression obtained in the trials (26).

Although at first glance the film may appear to block light, Surround actually increases net photosynthesis, and can provide secondary benefits to the trees' overall health according to Dr. Glenn. Surround keeps the tree cool so that photosynthesis can continue longer into the afternoon on hot days, after untreated trees have already shut down because of heat stress. In a two-year study, 'Empire', when sprayed during the first six to eight weeks after petal fall, had increased yields and increased red color. Growers have reported similar results with 'Stayman' and 'Gala'. An MSU study reported increased return bloom where Surround had been used the previous season. Growers in hot areas benefit from a marked reduction in sunburn damage, often 50% or greater.



Farmer profile:
Eric Rice, Middletown, Maryland

One of the first orchardists to use the kaolin spray, Eric Rice is confident the product will help him fare better in his packout next year. Rice, whose farm is certified organic, hopes to boost the percentage of select grade fruit from 50% to 70% of his apple crop. He expresses optimism about Surround's effectiveness against insects like the plum curculio, codling moth, leaf rollers, mites and aphids. "It doesn't bother beneficials," he says, adding that the ladybugs and other predators continued to thrive in the rich ground cover of clover and grass. Trials at the Rice orchard have shown over 90% control of the "big ones"—codling moth, plum curculio, and apple maggot. While Surround has also had a positive effect on fungal diseases like sooty blotch, fly speck, and fire blight, Rice cautions that it is not a panacea. It has had no effect on apple scab, a disease that often poses a bigger problem to growers than insect pests (initial research with kaolin focused on its potential for disease suppression, but the results were inconsistent.)

Although reluctant to make "overly aggressive claims" about the product, Rice says that Surround is far more useful than any other organic options available on the market. The only disadvantage he cites is the necessity of washing the clay off the fruit after harvest. Referring to the uniformly white appearance of the trees after spraying, Rice says, "It looks like Christmas. People who drive by sometimes stop to inquire if something is wrong."

Rice has been farming for the last twelve years, and raises several small fruits, including two dozen varieties of apples, on seventy acres in western Maryland. The apples are marketed through groceries in the Washington, D.C./Maryland area, a CSA, and a farmers' market in Dupont Circle. Plans are underway to start a mail order business via the Internet.

"Some people are picky," he says, "but direct marketing gives us a chance to talk to them about blemishes on the fruit." Rice also contracts with a commercial kitchen in Lancaster, in neighboring Pennsylvania, to make apple sauce and cider. He observes regretfully that there is not a single processing kitchen in the entire state of Maryland. "We've lost our farm infrastructure because of suburban sprawl."

Value-added products, according to Rice, require huge packaging and processing costs and are not an easy way to make money. "Moreover," he says, "I don't believe organics should be food only for rich people. Our applesauce, for instance, sells doesn't return a whole lot of money. Our apples in the ballpark of the conventional product and typically retail for under $2/lb. Our 'Gala,' a difficult variety to grow, sells for $1.29–1.59/lb." The margins are gained not from hefty premiums, he says, but by eliminating middlemen and absorbing their costs (as well as their work.)

Following a two-year trial of Surround, Rice now reports virtually no problems with insect pests, including the coddling moth, the apple maggot, and the plum curculio. Apple scab is treated with copper sprays pre-bloom, insecticidal soap, and summer oil—the last option, he notes, is not as effective. In addition, the leaves are cleared every fall, rotting or withered fruit is removed from the ground, and winter prunings are burned. "There's no single answer," says Rice, "but part of the solution lies in the use of disease-resistant cultivars, which we grow. 'Gala' is tremendously scabby while a number of antique varieties are fairly resistant. Still, every year we lose more to scab than to insect pests."

Rice relies on a variety of products to boost fertility—green sand, rock phosphate, compost from beef manure and leaf litter, fish meal, and pelletized poultry litter. For a cover crop, he uses clover and Companion grass, a cross between dwarf fescue and rye. Experience has led him to conclude that there is a correlation between high nitrogen availability and high disease pressure. Following the deliberate under-use of nitrogen, he has also noticed an increase in yields.

For information, contact Eric Rice at 6201 Harley Road, Middletown, MD 21769.
Phone: 301-371-4814.

Diseases

To identify diseases present at a specific orchard site, contact your Cooperative Extension Service.

Understanding genetic disease resistance

By plant breeders' design or by chance, a plant may exhibit natural, heritable resistance to a disease. Because disease-resistant cultivars have become increasingly important as growers try to reduce pesticide use, it is important to understand some principles of genetic disease resistance.

Resistance to a disease can be partial or complete (immune). Resistance exists on a continuum and may be expressed in terms such as "very suscepticle," "moderately susceptible," "susceptible," "moderately resistant," "resistant," "very resistant," etc. In some cases, numerical values have been assigned by researchers to represent a given level of resistance such as "60% resistant." If resistance is strong enough, the grower will not have to spray to control the disease.

It is important that the grower understand that given strong enough disease pressure — high levels of inoculum and the proper environmental conditions — medium levels of resistance can be overcome and the plant can suffer some infection.

Another principle to understand is that resistance to one disease never implies resistance to any other disease. A given variety may exhibit strong resistance to one disease, yet be highly susceptible to another. A good example of this is the cultivar 'Prima,' which is apparently immune to scab but so susceptible to cedar rust that it will defoliate if disease pressure is high. Growers who intend to forego all sprays for diseases need to be certain to get trees resistant to the diseases present in their area.

Lastly, the term tolerance is often used interchangeably with resistance. Technically, tolerance refers to the ability of a plant to undergo infection but without appreciable losses in growth or yield. A tree in good health will be tolerant to many diseases. For instance, a vigorous tree that suffered a cedar rust infection early in the season may show few signs of that infection later in the same season. The disease

Table 2: Approximate number of hours of continued wet foliage required for primary apple scab infection at different air temperature ranges (27).

32°–40°F	48 hours
40°–42°F	30 hours
42°–45°F	20 hours
45°–50°F	14 hours
50°–53°F	12 hours
53°–58°F	10 hours
58°–76°F	9 hours
76°–	11 hours

resistance/susceptibility of many apple varieties is charted in Appendix 2.

Apple scab

Apple scab, caused by the fungus *Venturia inaequalis*, is the most serious apple disease worldwide. The pathogen overwinters in dead leaves on the ground. Spores are released during spring rains, landing on and infecting leaves and fruit. Rain, length of leaf wetness, and temperature determine apple scab infection periods, and the degree of infection depends on the combination of these factors. Spores can germinate and cause infection only when they are kept wet over a certain minimum period of time at temperatures ranging roughly from 32° to 79° F. If they are not controlled, they will give rise to "secondary" infections later in the season. Primary and secondary infections may occur *simultaneously* early in the season, depending on weather conditions (27). If the grower is relying on protective-type fungicides, such as all organically acceptable fungicides, trees should be treated whenever there is a chance of primary infection (28).

Secondary infections begin when summer spores (conidia) develop in lesions on leaf and bud tissues, to be released during wet periods and disseminated throughout the tree. Secondary infections blemish and deform the apples, and will also weaken the tree. The number of primary and secondary infections in a year depends on the amount of rain. The warmer the weather, the more quickly conidia development follows primary infection (ranging from 18 days at 31°–40°, to 7 days at 71°–75°).

Fortunately, good scab infection prediction and management programs are available (check with suppliers listed in Appendix 1). The equipment necessary to monitor and detect infection periods includes a leaf wetness meter, a rain gauge, and a temperature recorder. These instruments areplaced in the orchard, or at the grower's home if the site is representative of orchard conditions (27).

The use of scab-resistant varieties is the best long-term strategy for organic growers to pursue, since such trees eliminate the necessity for applying fungicides. See Appendix 2 for names of scab-resistant varieties.

Apple scab can be controlled on susceptible varieties by timely sprays with fungicides. For the organic apple grower there are three commonly used materials: sulfur, lime-sulfur, and Bordeaux mixture. Bordeaux mixture is copper sulfate plus lime. All of these sulfur-containing fungicides can cause damage to the foliage or blossoms if used incorrectly, so heeding label cautions is important. All these fungicides are effective against scab spores but have to be applied before spores have a chance to germinate. To be effective, the trees must be diligently sprayed or dusted before, during, or immediately after a rain from the time of bud break until all the spores are discharged. If these primary infections are prevented, there will be less need to spray for scab the remainder of the season (29). If primary infections do develop, spraying will have to be continued throughout the season.

In most areas, applications of fungicides—in this case, sulfur products—are based on the phenological development of the trees. Spraying begins in the spring when a wetting period (rain) is sufficiently long at the existing temperature to produce an infection. Spraying is then repeated every 5 to 7 days, or according to rainfall, until petal fall. It is important with protective-type fungicides, such as sulfur, to insure that new tissues on rapidly expanding young leaves and fruit are always covered with fungicide during an infection period.

Several types of synthetic fungicides—including the sterol inhibitors and the strobilurins—seem to combine a high level of safety with the qualities apple growers need for reducing the number of fungicide sprays. One of the sterol inhibitors labeled for apples, myclobutanil, has a broad target range, meaning it works on all the major early season apple fungal diseases—scab, rust, mildew. It also has excellent kickback action, allowing growers to wait for infection periods before spraying, no phytotoxicity problems, and eradicative potential for primary scab inoculum (30). In terms of safety, myclobutanil scored negative on the Ames tests for mutagenicity and carcinogenicity and has a very low acute toxicity (LD-50, 1600 mg/kg body weight of rat) (31). Unfortunately, myclobutanil appears to provide little control of the summer diseases—sooty blotch, black rot, bitter rot, and white rot (more on these below).

Because the scab fungus overwinters on the fallen apple leaves, small-scale growers can largely eliminate the primary scab inoculum and control the disease by raking and destroying (burying, burning, composting) the fallen leaves.

Other approaches to reducing or eliminating the primary inoculum might include anything that would hasten the breakdown of the fallen leaves. Fall applications of urea have resulted in good primary scab control (32), indicating perhaps that other fertilizer materials could do likewise. There is evidence that earthworms aid in scab control by speeding the breakdown and incorporation of the fallen leaves.

Fall fungicide applications also have shown promise for primary scab control. One of the major problems with using sulfur compounds is phytotoxicity, but this concern could be largely circumvented by spraying in late autumn (after harvest but before leaf fall) when it is not very important if the leaves are damaged. Research with other fungicides has proven the basic efficacy of this approach.

Other unconventional approaches to scab control that show some promise include a variety of plant extracts (33) and even compost tea (34). Refer to ATTRA's *Compost Teas for Plant Disease Control* for more information.

Suppressing diseases with compost

Organic farmers and gardeners have long touted the disease-suppressive benefits of compost. Recent research has confirmed this natural suppression, made some headway in understanding it, and developed methods for producing *consistently* suppressive composts, a major step toward greater use by growers.

Plant pathologists distinguish two types of disease suppression in compost (and in soil). *General* suppression is attributable to many different microorganisms that either compete with pathogens for nutrients or produce general antibiotics that reduce pathogen survival. *Specific* suppression is attributed to one or a few organisms that parasitize the pathogen or induce systemic resistance *in the plant* to specific pathogens (this works in much the same way as a vaccination).

If composts can be produced on a large scale with reliable and quantifiable disease suppressive qualities, growers will be more likely to use them in place of fungicides. The nursery industry is already using disease-suppressive compost widely and routinely, and its widespread use in crops such as apples is likely in the near future (35).

Fire blight

Fire blight is caused by the bacteria *Erwinia amylovora,* which can be transmitted by bees, aphids, and other insects, as well as by wind and rain. Warm, wet conditions foster the bacteria's reproduction and spread within and among trees, and large numbers of new infections can occur within minutes after rain or heavy dew hits. Fire blight will be a problem only in years when the weather is conducive to its spread. Affected branches wither and turn black or brownish black, as if scorched. Most branch tips, once infected, wilt rapidly, taking on the characteristic shape of a "shepherd's crook". Having gained entry to the tree through blossoms or lush new growth, the bacteria spread internally through the stems, and begin to work towards the roots. In resistant varieties, the bacteria rarely invade beyond young wood. (See Appendix 2 for information on resistant varieties.) Under the bark, the bacteria form a canker where they will overwinter, surviving to infect more trees the next year.

Once infection has occurred, there is no spray or other treatment, beyond quickly cutting out infected limbs, that will minimize damage. Sprays of agricultural grade streptomycin have been the standard commercial control since the 1950's, applied at early bloom to *prevent* infection. Organic certifying groups are mixed on their acceptance of streptomycin, an antibiotic produced by cultured fungi, for fire blight control. Bordeaux mix and other copper formulations sprayed at green tip stage are organic options that provide some protection from infection. For best results, these should be applied to all the trees in a block, not only the blight-susceptible varieties (36).

In 1996 a new biocontrol product called BlightBan™ came on the market. BlightBan is a formulation of the bacteria *Pseudomonas fluorescens*, strain A506. *P. fluorescens* is a non-pathogenic competitor with *E. amylovora*, and as such does not directly kill propagules of *E. amylovora*; rather, it occupies the same sites that *E. amylovora* would, provided it gets there first. Therefore, in order to be effective, BlightBan should be applied to newly opening flowers (multiple applications will probably be necessary) or applied in combination with streptomycin (*P. fluorescens*, strain A506 is resistant to streptomycin). In fact, research indicates that fire blight suppression is best when streptomycin and BlightBan are combined.

Using the two together can reduce the amount of streptomycin sprayed each year, which may help to protect the antibiotic's effectiveness. (In some Western apple-growing areas, *E. amylovora* has developed resistance to streptomycin.) By itself, BlightBan may provide 50% suppression. It cannot be used in combination with copper sprays. The biocontrol bacteria live only about three weeks in the orchard, and there is no carry-over from year to year (37, 38). BlightBan is marketed by Plant Health Technologies (see Appendix 1).

A computer software program called Maryblyt™ is available to help guide the grower in timing

Summer cuts questioned

"Whether to cut and how to cut out active blight infections during the growing season is a subject of continuing debate. We recommend a very aggressive cutting of all branches that show symptoms only when the incidence and distribution of infections is light and the job can be completed quickly.

"When blight is moderate to heavy, the success of even the most well-intentioned cutting effort is questionable. In such cases, the focus…should be on removing infections high in the tree, those that threaten the central tree stem, and removing severely damaged trees quickly.

"While the bacteria are often present in healthy tissues far ahead of visible symptoms, high levels of reserve carbohydrates in living bark tissues deny the pathogen water and limit symptom development. Cutting through such colonized but symptomless branches breaches this natural defense and induces the formation of cankers around wounds, even where both bark surface and pruning shears have first been sterilized with bleach or alcohol.

"To avoid new cankers around cut sites, make cuts during the growing season only into two-year-old or older wood and at least 4 to 5 inches short of the next healthy branch union, leaving an "ugly," naked stub. Cankers that form around the cut can be removed during the regular dormant pruning effort when the temperature is too cold to allow the bacteria to form another canker. Failure to follow this "ugly stub" procedure can actually increase the number and distribution of inoculum sources in the orchard that will fuel yet another epidemic the next season."

—**Paul W. Steiner (36)**

A promising biocontrol technique employing honeybees as couriers of beneficial bacteria is under development by USDA scientists. The researchers place the beneficial bacteria in a shallow tray at the hive entrance. The bees walk through the tray, pick up the beneficial bacteria, and deliver it to the flowers during pollen and nectar collection (39)

antibiotic sprays. The grower enters daily minimum and maximum temperatures, rainfall, and stage of blossom development, and the program predicts infection events and symptom development for most phases of fire blight. The

Maryblyt program may be purchased from Gempler's, Inc., and further information on the program is available at the Kearneysville web site (see Appendix 1).

A rule of thumb is to spray just before rain or heavy dew is expected during bloom, when average temperature is 60°F or higher, and to repeat in four days if these conditions persist. "Routine" sprays, in the absence of wet, warm conditions, are often unnecessary. Overuse of streptomycin should be avoided because of the danger of inducing resistance in the pathogen population. Again, streptomycin is not effective against the "shoot blight" phase and should never be used when symptoms — "burned" branch tips — are present (36).

Proper sanitation is the most important measure for controlling fire blight once it has infected a tree. During the winter all blighted twigs, branches, and cankers should be cut out about 10 cm below the last point of visible infection, and burned. After each cut, the shears should be dipped in alcohol or a strong bleach or Lysol™ solution—1 part household bleach or Lysol to 4 parts water—to avoid transmitting the disease from one branch to another. Lysol is less corrosive than bleach to the metal parts of the pruners.

Fire blight development is greatly favored by the presence of young, succulent tissues. Where fire blight is a problem, cultural practices that favor moderate growth, such as low fertilization and limited pruning, are recommended.

Powdery mildew

Powdery mildew is primarily a foliar disease, but it can affect fruit if the infection is severe. Some apple varieties, such as 'Braeburn,' are so susceptible that infection curls, distorts, and discolors leaves. In such cases, photosynthetic capacity is reduced and tree vigor and health suffer.

Areas where spring and summer humidity are high are most likely to foster powdery mildew problems. There are resistant varieties (see Appendix 2), and mildew can be controlled with many fungicides including the aforementioned sulfur compounds.

Cedar apple rust

The fungus that causes this disease moves back-and-forth between Eastern red cedars (actually junipers—not true cedars) and apples, and so can be a major problem where Eastern red cedars are endemic. In order to complete its life cycle this fungus *must* spend part of its life on Eastern red cedar; therefore, it is theoretically possible to eliminate the disease by eliminating the cedars within a given area. However, the spores can be windborne up to 2–3 miles (40), so eradication of the disease in this manner is often impossible or impractical.

Nonetheless, if cedars are not too numerous on a given site, their removal around the immediate orchard vicinity can certainly reduce the inoculum reaching the apple foliage. There are many rust-resistant apple varieties. Only a few varieties, most notably 'Golden Delicious' and its progeny, are susceptible to the point of defoliation (see Appendix 2).

Many fungicides are effective against rust, including the sulfur compounds. If the grower is observant, he or she may be able to time the sprays to coincide with the springtime appearance of orange gelatinous "horns" on the galls on the cedar. This bizarre-looking structure is actually the fruiting stage of the fungus. The "horns" release the spores that infect the apple trees.

The summer rots

Where summers are warm and humid (including most of the Eastern U.S.), the summer rots—black rot, bitter rot, and white rot—can be problematic. In general, these rots are more pervasive in the Southeast than elsewhere, but one or more of them can become a problem in almost any area if the particular growing season is conducive.

Little attention has been given in university trials to screening for resistance to the summer rots. One reason for this lack of research has been the general perception that there simply wasn't resistance, "just degrees of susceptibility."

However, on closer examination, Dr. Curt Rom (41) of the University of Arkansas has noted distinct differences among cultivars in relation to bitter rot susceptibility/resistance. Cultivars rated as moderately to very resistant by Dr. Rom include Jonalicious (Daniels), Jonadel, Jonagold, Winesap, Melrose, Red Delicious, and Rome Beauty. Cultivars rated as moderately to very susceptible include Priscilla, Liberty, Elstar, Mutsu, Golden Delicious, Idared, and Stellar.

A New Era of Fungicides

As many "old-guard" fungicides are phased out by environmental and health regulations, several new classes of chemistry are yielding safer, more ecologically sound replacements. The new classes of fungicides for perennial tree crops include DMIs (or sterol inhibitors), strobilurins, hydroxyanilides, pyrimidinamines, and phenylpyrroles. Some of these have broad-spectrum activity, but none are effective against all fungal pathogens of apples. Many are not at all broad- spectrum, but are highly effective against the pathogens they target. A defining characteristic of most of these new compounds is "single site mode of action" on the fungus—in other words, the fungicide controls the fungus by disabling only one of its essential life-sustaining processes. This makes them radically different from familiar fungicides such as Captan™, and means that they require a new way of thinking about and working with fungicides. This "new way" comprises some basic tenets of the IPM approach: more careful assessment of the targeted pathogens, including careful observation of their cycles in the orchard, more precise spray timing, and conscientious rotation of fungicides from year to year. Such measures are crucial both for achieving control with the new fungicides and for ensuring that the strains of fungi endemic to the orchard do not develop resistance to the chemicals.

The new fungicides are not as environmentally persistent as are their predecessors, making them safer for workers in the orchard and for the environment. Compounds such as phenylpyrroles and strobilurins are photolytic, meaning they break down in sunlight. All of the new fungicides are degradable by microorganisms. Ecologically this is very good news. On the downside, it means that more frequent sprays will be necessary for good control. However, the newer chemicals are also generally effective at far lower use rates; for example, where 20 pounds per acre of sulfur might be typical, only 4 ounces of the strobilurin Abound™ will be needed, and will provide far better control.

The importance of resistance management cannot be over-emphasized. Since many of these compounds have a single-site mode of action,the pathogen need undergo only a single genetic mutation, or possess a single genetic variation, to gain resistance to the fungicide. This means that rotation among several different fungicides must be the rule. Whereas before rotations between products was recommended, now rotations between classes of products is key. The risk of induced resistance is greatly diminished when growers know the class of each fungicide and rotate every time they spray. As always, better management and ecological dividends call for extra research and forethought on the part of the low-spray grower (43).

Ed Fackler (42), an Indiana low-spray orchardist, has noted that cultivars that ripen with 'Gala' (about September 10 at his site) or earlier suffer little from the summer rots. Some cultivars that have been reported to be especially prone to at least one of the summer rots include Liberty, Empire, King David, Priscilla, Golden Delicious, Freedom, Wolf River, Rome Beauty, Jonathan, Blushing Gold, and Sir Prize. Other cultivars that seem to suffer little from the summer rots include Stayman, Arkansas Black, Dayton, Gala, Melrose, Akane, and Fuji (42, 10).

For control in low-spray and organic orchards, growers should emphasize cultural techniques for suppression of the causal organisms of these rots. Such techniques would include pruning out of diseased wood, removal of fruit mummies, pruning for light penetration and air circulation, and avoidance of poor sites.

Captan™ appears to be the most effective synthetic for summer rot control (41). Dormant sprays of the copper and sulfur fungicides can reduce the overwintering inoculum of the summer rots. For in-season protection, sulfur sprays can be effective, but sulfur applications made when temperatures exceed 90°F. can cause leaf burn. The finely ground, liquid formulations seem to be the least damaging in this regard.

Sooty blotch and fly speck

These two fungal diseases are almost always found together even though they are distinct from one another. The effects of both diseases are almost purely cosmetic but can render the fruit unsaleable in the conventional market-place (44).

Again, there appears to be no resistance, per se. However, these diseases are less apparent on darker fruit; yellow fruit seems to emphasize the problem. Because the fungi are taking nourishment on the waxy surface cuticle of the apple (45), very waxy types can be more prone to these diseases while cultivars with little wax—such as the russets (Roxbury Russet, Golden Russet, etc.)—may be little bothered. Also, very early-ripening cultivars, such as Williams Pride, Pristine, and Priscilla, generally escape sooty blotch and fly speck simply by virtue of their earliness.

Where these diseases are problematic, most commercial orchardists use multiple sprays of fungicides through the summer for control. University of Georgia research indicates that between 6 and 10 sprays of Captan™ will be necessary most years to control these disorders. Dr. Dan Horton (46) at the University of Georgia is part of the research team that conducted low-spray apple research under a 1988 LISA grant. They relied on a post-harvest soak (1:100 parts household bleach to water) for sooty blotch control. The apples were left to soak for 15 minutes, rinsed, and allowed to dry. Post-treatment residue analysis showed less than 100 ppm hypochlorite (bleach) residues on the apple skin, and no residues in the flesh. Growers in other states should check with their state departments of agriculture for information on the registration status of this method.

The sooty blotch/fly speck problem provides one example where education of consumers, especially a particular clientele, can allow for a reduction in pesticide sprays. Orchardist Carolyn Ames (11) reports little or no consumer resistance to apples with sooty blotch and fly speck when she markets at the Fayetteville Farmers' Market in northwest Arkansas. She attributes this mostly to the fact that she provides taste samples to her clientele, and taste then becomes the primary purchasing motivation.

If buyers do ask about the sooty appearance of the apples, she explains that the fungi are completely superficial, do not hurt the apple or the consumer, and would otherwise have to be controlled by fungicide sprays up to harvest. She finds that most customers are completely reassured by her explanation, and express appreciation of her ecological growing methods.

The rootstock factor

Apples can be grown on a variety of rootstocks, which can be divided into seedling and clonal (genetically identical) types. Clonal types can be further divided by size into dwarf, semi-dwarf, and semi-standard.

There are currently about eight apple rootstocks in common commerce, designated (in order from the most dwarfing to the least dwarfing) M.27, M.26, M.9, Mark, M.7, MM.106, MM.111, and seedling. Each has its respective strengths and weaknesses, many of which may impact pest control.

Generally speaking, the smaller the tree the easier it is to spray. A study at New York State Agricultural Experiment Station indicates that organic insect control in a dwarf orchard would cost approximately $314/acre compared to $1200-3700 for an orchard on seedling rootstocks (47).

However, dwarfing rootstocks are not without significant pest problems. M.27, M.26, and M.9 are quite susceptible to fire blight. M.27, M.26, and MM.106 are susceptible to phytophthora root rot. All of the size-controlling rootstocks except those with the "MM" designation are susceptible to wooly aphids. Most seedling rootstocks are susceptible to wooly aphids also, but are more tolerant of wooly aphid feeding damage than the more dwarfing rootstocks.

Furthermore, there appears to be a general correlation between intensity of dwarfing and non-pathogenic disorders such as chronic nutrient deficiencies or toxicities. As an example, all rootstocks the size of Mark and smaller are susceptible to apple measles, a manganese toxicity problem. Most nutrient problems related to dwarfing can be taken care of with careful attention to soil fertility and pH.

Borers can be a problem for any rootstock, but the more vigorously growing rootstocks (the larger ones) have considerably more tolerance for damage than less vigorous stocks. Dwarf trees require more frequent watering than larger trees. If allowed to become drought stressed, dwarf trees are much more susceptible to serious damage from borers than are larger trees.

Matching the right rootstock to the grower's management plan (especially considering pest control, site, and water) is a very important decision that could ultimately make the difference in success or failure. Consultation with the state Cooperative Extension horticulture specialists is recommended.

Mammal and bird pests

Mammals are often overlooked by the beginning orchardist as important orchard pests, but deer and voles—the two most important mammal pests—can easily put a young orchard out of commission in one short season. Fruit-eating birds are usually more troublesome on small fruits (grapes and berries), but can cause serious economic damage to apples. For information on controlling mammal and bird pests, see the ATTRA publication *Overview of Organic Fruit Production*.

Farmer profile:
Tim Bates, The Apple Farm, Philo, California

Northwest California's Mendocino county has a higher percentage of organic farmers than any other county in the U.S.—some 12 to 16% of its growers are organic. Tim Bates, who has farmed here for the past fifteen years, tends fifteen acres of apples, an acre of pears, some peaches, plums, and quince. He converted to organic in 1987 and is certified by the CCOF (California Certified Organic Farmers).

The codling moth, which emerges in mid-April, is Bates' most worrisome insect pest. Damage to the apple crop can range from 6–13% each year. Bates relies on a varied set of tools to control the moth—including sticky traps to monitor damage, mating disruption through pheromones, and release of predatory trichogramma wasps.

In 1998, researchers at the University of California released an imported parasitic wasp from Kazakhstan on his farm, as part of an ongoing experiment in codling moth control. Moth damage to the apple crop that year was approximately 2–3%. Bates observes that the wasp has the potential to ease codling moth pressure significantly, but trials are still underway and it may be too early to draw conclusions.

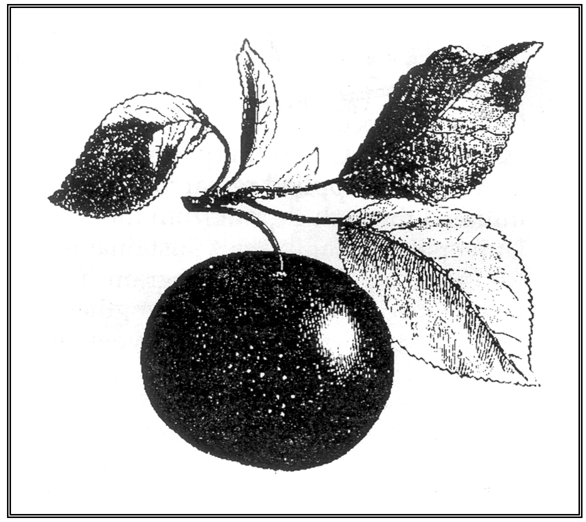
Apple scab is the most serious disease problem, and often causes more damage to the crop than the codling moth. In a good year scab damage averages 3–7%, in a bad year 10–20%. If Bates did not intervene, scab could destroy up to 60% of his crop. Outbreaks are especially bad in years of heavy rainfall. For control he relies primarily on the application of lime sulfur and sulfur sprays, March through mid-May. The sprays also help to control powdery mildew.

Rosy apple aphids, also a problem, are kept in check by the release of beneficial insects like the green lace wings and the *Aphidoletes aphidimyza*, a type of midge. Bates no longer uses insecticidal soap, finding it sticky and messy, and ineffective against aphids.

Compost, says Bates, is the key to pest control. He applies compost to the apple trees every year. However, compost tea applied as a foliar spray did not seem to stave off pests. Bates uses biodynamic preparations to nourish both soil and plants. Some (prep 501) are applied as a post-bloom foliar spray and some (prep 500) are disked in with the cover crop in spring. Others (preps 502 to 507) are added to compost. Refer to the ATTRA publication *Biodynamic Farming & Compost Preparation* for more information on these preparations.

Clover is the primary cover crop, and a third of the farm is cultivated with it each spring. Lime is applied every 4 to 5 years. Seaweed sprays are also applied pre-bloom, post-bloom, and a couple of times during the season provide essential nutrients. Calcium is applied as a foliar spray.

More than sixty varieties of apples are grown on the farm. Chief among these is 'Golden Delicious', which constitutes 60% of his crop. Owing to insect and disease pressure, Bates considers himself lucky if, in any given year, he can get 50% of his crop into the fresh fruit



market. Most of the fresh fruit is sold to the wholesale district in San Francisco, some is delivered directly to retail stores, and the rest is sold at local farmers' markets. The other half of the crop is processed at the local cannery, and on the farm through a certified kitchen. On-farm products include hard cider, cider vinegar, apple syrup, and balsamic vinegar. These are marketed through a farm store and via mail order. Bates also contracts with the cannery to produce apple juice, most of which he sells on the farm. The rest is sold to local stores. Organic prices, which he estimates average roughly 1½ times that of conventional prices, are stabilizing. His 'Golden Delicious' retail for $.80–$1 per pound. The more exotic varieties average $1.40 per pound.

For information contact Tim Bates, The Apple Farm, 18501 Greenwood Road, Philo, CA 95466. Phone: 707-895-2333.

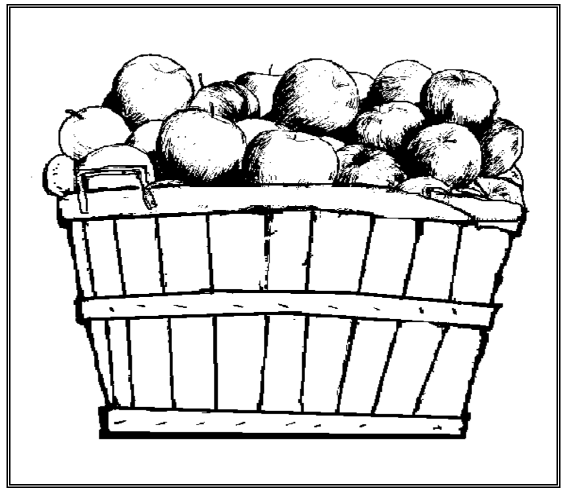
ECONOMICS AND MARKETING OF LOW-SPRAY AND ORGANIC APPLES

Geography plays an important role in determining the feasibility of commercial-scale organic apple production. Would-be organic growers in the Eastern half of the country must realize that they are likely to face production costs at least triple those faced by growers in the West. Management of the plum curculio alone is a very serious economic and logistical problem. While PC-damaged apples can be used for cider and other processed goods, these require expensive processing and storage equipment, and cider usually brings a lower return than fresh fruit.

In addition to the plum curculio, a host of other pests and insects make organic apple growing in the East difficult at best, and costly for sure. A New York study (48) indicated that using only organically acceptable botanical pesticides would cost approximately $686 per acre and yield about 70–75% clean (fresh market grade) fruit. In contrast a program using Imidan™ would cost about $20 per acre and result in over 90% clean fruit. Obviously, the organic grower would have to receive premium prices to recoup the higher production costs. Even for growers in the West, organic apple profitability appears to depend on price premiums.

The "Alar incident" of 1989 prompted prices for organic apples to rise as high as $60 for a 20-pound box. Prices did not stay that high for long, and by the end of the year organic apples were selling for only 25–30% more than conventionally grown apples. Also in 1989, a University of California study (49) concluded that premium prices, not cut-rate production costs, represented the best hope for profits in organic apple production. Dr. Roberta Cook, one of the authors of the study, cautioned that supply is rapidly catching up with demand and that growers should not leap into production based on perceptions of lower input costs and guaranteed premiums.

Ten years later, Cook's predictions appear to have come true. Supply of organic apples has increased dramatically and seems set to continue increasing. Whether growers in the West will have access to premium prices at the wholesale level is becoming increasingly uncertain. The number of organic apple growers in Washington is projected to increase from 74 in 1998 to 114 in the next three years (50), with organic apple production in the state expected to triple within the next two years (51). Some industry experts believe that the number of acres being converted to organic production will lead to an oversupply of organic apples, depressing prices. According to a USDA-FAS study on Washington organic production (51), domestic demand for organic apples "is fast reaching the saturation point", and the authors recommend



developing the export market, where growers will face increasing competition from countries such as China. In 1997, China produced nearly four times as many apples as the U.S., and China is predicted to produce 40% of the world's apples by 2005 (52).

Given this market situation, any potential organic apple producer needs to carefully consider the economics of production in his or her area before making any investments. It may be possible for the small grower to receive a high enough price to cover costs of production by relying on direct marketing. However, in the East, the difficulty and expense of growing apples organically makes it extremely unlikely that the grower can compete with the large supply of more cheaply produced organic apples from the West in any but the most limited local markets.

Considering the economics of Eastern organic production, a much more feasible alternative for the Eastern grower is to use low-spray and other environmentally responsible techniques to produce apples. While this alternative rules out

Holistic Management and Orchard Planning

The vagaries of the market and the intrinsic complexities of organic and low-spray management demand that the grower, whether beginning apple production or re-thinking an existing orchard, take special care in planning ahead and monitoring results. Holistic Management is a simple decision-making framework that incorporates values-based goal setting, the appropriate use of tools, financial planning, land planning, biological planning, and careful monitoring of effects. All these aspects are managed as a whole unit. First, the "whole" is defined by forming answers to underlying questions, such as "Why am I farming? What do I mean to accomplish? What kind of world do I want for my grandchildren?" By developing principles based on these deeper considerations, the grower develops a powerful guidance system for making specific choices later on.

Holistic financial planning often seems to turn conventional financial planning on its head. One key distinction is that profit is planned before any expenses are allocated. Once the profit is allowed for, expense dollars are allocated sequentially where they will do the most good. This approach helps the grower avoid a common mistake that can be fatal—allowing expenses to nearly equal the planned gross income, leaving very little room for profit. For more information, request the ATTRA publication Holistic Management: A Whole-Farm Decision Making Framework.

receiving organic premium prices, the burgeoning "eco-labeling" movement may offer some benefits. An excellent example is the Core Values Northeast program. Recognizing the difficulty of growing apples organically in the Northeast, the program allows growers who are accredited in knowledge-based biointensive Integrated Pest Management (IPM) production methods to label their apples with the Core Values seal. This label differentiates their apples and allows them to charge a higher price, while benefiting from the promotional aspects of the program, including consumer education. The program's literature points out that natural pesticides, for example, can be much worse for the environment than synthetics, particularly in dosages required for even partial pest and disease control. For Core Values Northeast contact information, see Appendix 1.

The prudent small grower in the East, whether low-spray or organic, should retain a niche market strategy focusing on retail sales. By carefully developing this type of market, the grower can maintain an adequate profit margin while personally connecting with and educating customers on the advantages of his or her apples (fresher, fewer sprays, greater variety choice, locally grown, etc.). For more information and ideas along these lines, see the ATTRA publications *Direct Marketing* and *Resources for Organic Marketing*.

A common strategy for organic and low-spray growers who have a high percent of culls is to integrate processed apple products into a marketing plan. Not only will cider, preserves, and other processed products enable the grower to sell otherwise unmarketable apples, they may even add to the profit margin through "value-added" marketing. This will require special equipment and research into health regulations, including requirements for certified processing kitchens. Under new federal fresh juice labeling regulations, cider makers must either pasteurize (and meet a bacterial elimination performance standard) or affix a label to the container which states:

> "WARNING: This product has not been pasteurized and, therefore, may contain harmful bacteria that can cause serious illness in children, the elderly, and persons with weakened immune systems."

The new regulations still face legal challenges from the cider industry, but as they stand they apply to all producers regardless of scale (53). The latest news on the cider issue (or "cider crisis") can be found at the "Virtual Orchard" website (see Appendix 1).

Conclusion

To many interested in sustainable agriculture, apple orcharding perhaps symbolizes two extremes: 1) An Eden-like permanent

> *"Walking west I longed for a wellspring.*
> *As high as the hawk flies the heavens were hazy.*
> *In that wild kingdom nowhere was comfort*
> *Yet all the apples I ate were awesome."*
> —Anon.

agriculture—an arboriculture where trees yield their perfect fruits without labor or coaxing, and 2) A Faustian bargain with the agrichemical companies where everything good and natural has been sold out for a cosmetically perfect poisoned apple. Both images have attracted people to the idea of organic apple orcharding—the first for its simple, idyllic appeal and the second for the challenge of reforming the evils of the current system.

As is often the case, reality falls somewhere between these two extremes. Agriculture is necessarily an imposition on nature, and apple orcharding is no exception. However, we are struggling to learn to impose with a lighter touch, and the more we look, the more nature is revealing. Such things as pheromones, biological controls, and a better understanding of disease and pest life cycles are providing opportunities to craft "softer," more sustainable orchard systems.

Whether or not a low-spray or organic apple orchardist can build an economically and ecologically sustainable business is dependent on many factors, not the least of which is self-education. Because of the many potential pitfalls, it is highly recommended that the aspiring low-spray or organic orchardist consult appropriate texts, journals, Cooperative Extension Specialists, and—most importantly—other orchardists for additional information. The following references and the **Resource List** (Appendix 1) should be helpful in this regard. See also ATTRA's *Overview of Organic Fruit Production* and its resource list.

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Department of Entomology
University of Massachusetts
Amherst, MA 01003
413-545-2284

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Ames' Orchard & Nursery
18292 Wildlife Rd.
Fayetteville, AR 72701
501-443-0282

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Gary J. Puterka
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45 Wiltshire Rd.
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304-725-3451 (Glenn ext. 321; Puterka ext. 361)
e-mail: mglenn@afrs.ars.usda.gov
gputerka@afrs.ars.usda.gov

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Dept. of Horticulture
University of Arkansas
Fayetteville, AR 72702
501-575-2603

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Rocky Meadow Orchard & Nursery

Rt. 2, Box 2104
New Salisbury, IN 47161

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Dept. of Plant Pathology
North Carolina State University
Raleigh, NC 27695
919-691-7151

46) Dr. Dan Horton
Extension Entomology Dept.
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Athens, GA 30602
404-542-3824

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Univ. of California, Davis
Davis, CA 95616

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APPENDIX 1:
Resource List.

APPENDIX 2:
Disease Resistant Apple Varieties chart.

APPENDIX 3:
Pickel, Carolyn, Richard Bethell, and William Coates. 1986. Codling Moth Management Using Degree Days. IPM Manual Group, University of California, Davis. 7 p.

APPENDIX 4:
Prokopy, R. and D. Cooley. 1991. Very low-spray apple growing. Fine Gardening. No. 22. p. 46–49.

Appendix 1: Resource List

- ATTRA publications
- Books
- Periodicals
- Web resources
- Plants
- Supplies

ATTRA publications

Overview of Organic Fruit Production
Organic Certification
Integrated Pest Management
Farmscaping to Enhance Biological Control
Compost Teas for Plant Disease Control
Biodynamic Farming & Compost Preparation
Direct Marketing
Resources for Organic Marketing
Holistic Management: A Whole-Farm Decision Making Framework

Books:

Agnello, A., et al. 1993. Apple IPM: A Guide for Sampling and Managing Major Apple Pests in New York State. Cornell Cooperative Extension, Cornell University, Ithaca, NY. 64 p.

If you're serious about IPM for apples, here is a good exposition of this sometimes complex subject. Otherwise, this publication is still very useful for its excellent color photographs of eastern U.S. pests included as separate "Insect Identification Sheets." This book is available by mail from the following address. Send a check for $12.00 payable to Cornell University (NY residents add applicable tax).

Cornell University
Media Services Resource Center
7-8 Cornell Business & Technology Park
Ithaca, NY 14850
607-255-2080

Beers, Elizabeth, et al. 1993. Orchard Pest Management: A Resource Book for the Pacific Northwest. Good Fruit Grower, Yakima, WA. 276 p.

Very slick, professionally done book. Good life-cycle illustrations and excellent photographs. A "must" resource for commercial apple growers in the Pacific Northwest. Insects and other arthropods are covered; diseases, etc. are not. Available for $35.00 (plus $3.50 postage and handling) from:

Good Fruit Grower
105 South 18th Street, Suite 217
Yakima, WA 98901
800-487-9946
http://www.goodfruit.com

Edwards, Linda. 1998. Organic Tree Fruit Management. Certified Organic Associations of British Columbia, Keremeos, B.C., Canada. 240 p.

Not as slick and professional as some, but full of the real-life experiences of organic growers. Might be especially helpful for questions regarding organic fertility management. For Northwest only. Available for $38.00 (plus $3.50 postage and handling) from Good Fruit Grower (see previous item).

Ellis, Michael. 1992. Disease Management Guidelines for Organic Apple Production in Ohio. Ohio State University, OARDC, Wooster, OH. 33 p.

*This publication is exactly what it says in the title – guidelines (not a systematic, calendar spray approach) and only for diseases, not insects. It is NOT a comprehensive guide to organic production in Ohio. Still, lots of good information for Eastern growers. Available **free of charge** from the address below. A web version is available too, at:*

http://www.caf.wvu.edu/kearneysville/organic-apple.html

C & T Department
OSU/OARDC
1680 Madison Ave.
Wooster, OH 44691
330-263-3700
e-mail: martin.881@osu.edu

Howitt, Angus H. 1993. Common Tree Fruit Pests. Michigan State University, East Lansing, MI. 252 p.

A few pictures are fuzzy, and a few major pests (at least for organic and low-spray growers) are inexplicably absent (e.g., roundhead and flathead borers), but it is still a useful resource, especially for eastern growers. To order send a check for $10.00, payable to Michigan State University, to the following address. Specify publication no. NCR63.

Michigan State University
Bulletin Office
10-B Agriculture Hall
East Lansing, MI 48824-1039
517-355-0240

Jones, A. L. and H. S. Aldwinkle (eds.). 1990. Compendium of Apple and Pear Diseases. American Phytopathological Society, St. Paul, MN. 100 p.

A very comprehensive guide to all the things that can afflict your trees and crop. Excellent color plates. To order send $37.00 (plus $5.00 shipping and handling; MN residents add applicable tax) to:

American Phytopathological Society
3340 Pilot Knob Road
St. Paul, MN 55121-2097
800-328-7560

Page, Steve and Joe Smillie. 1995. The Orchard Almanac. Third edition. AgAccess, Davis, CA. 154 p.

Using a season-by-season format, the authors provide an easy-to-use, understandable approach to both low-spray and organic apple production. One of the best guides for the East. Available from Fertile Ground Books for $16.95 (plus $2.50 shipping and handling book rate, or $5.00 UPS; CA residents add applicable tax).

Fertile Ground Books
P.O. Box 2008
Davis, CA 95617-2008
800-540-0170
http://www.agribooks.com

Peterson, Brooke A. (ed.) 1989. Intensive Orcharding. Good Fruit Grower, Yakima, WA. 187 p.

Guide to growing apples in high density systems using dwarfing rootstocks. Currently out of print. May be available through interlibrary loan or searchable by a used book dealer. Otherwise check with Good Fruit Grower (see second item above) for reprint status.

Phillips, Michael. 1998. The Apple Grower: A Guide for the Organic Orchardist. Chelsea Green Publishing, Wite River Junction, VT. 242 p.

To date, the best guide for strictly organic growing in the East. Available from the publisher for $35.00 (plus $6.00 shipping and handling; VT residents add applicable tax).

Chelsea Green Publishing
P.O. Box 428
White River Junction, VT 05001
800-639-4099

University of California Statewide Integrated Pest Management Project. 1991. Integrated Pest Management for Apples & Pears. Division of Agriculture and Natural Resources Publication 3340. University of California, Oakland, CA. 214 p.

An excellent, comprehensive publication from the University of California. Covers insects, mites, weeds, diseases, vertebrate pests (birds, deer, etc.), even climatic and other growing information for the various regions of California. To order send a check for $30.00 (plus $5.00 shipping and handling; CA residents add applicable tax) made payable to U.C. Regents.

University of California
Division of Agriculture & Natural Resources
Communication Services-Publications
6701 San Pablo Ave.
Oakland, CA 94608
800-994-8849

Whealy, Kent. 1993. Fruit, Berry and Nut Inventory. 2nd edition. Seed Saver Pubs., Decorah, IA 366 p.

Descriptions of various fruit cultivars extant in U.S. nursery trade. Available from the publisher for $22.00 (plus $3.00 shipping and handling).

Seed Savers Exchange
3076 N. Winn Road
Decorah, IA 52101
319-382-5990

Periodicals:

American Fruit Grower
Meister Publishing Company
37733 Euclid Ave.
Willoughby, OH 44094
440-942-2000
Monthly. $15.95/yr.

Good Fruit Grower
1005 Teiton Dr.
Yakima, WA 98902
509-575-2315
$30/eight issues per yr.

Fruit Growers News (formerly Great Lakes Fruit Growers News)
POB 128
Sparta, MI 49345
616-887-9008
Monthly. $9.50/yr.

Pomona
North American Fruit Explorers
1716 Apples Rd.
Chapin, IL 62628
(no phone)
Quarterly. $10/yr.

Web resources:

http://orchard.uvm.edu

UVM Apple Orchard site (University of Vermont). "Extension and research for the commercial tree fruit grower in Vermont and beyond." Horticulture, IPM, weather, archived newsletters, searchable, links, e-mail newsletter.

GROWER-AIM is an e-mail discussion group for New England apple growers. To subscribe, send an e-mail to listserve@list.uvm.edu *with the subscribe command as the first line of your message along with the list name and your first and last names (example: subscribe grower-aim Henrietta Somebody.) Once you are on you may send a message to everyone on the list by sending an e-mail to:* grower-aim@list.uvm.edu.

http://orchard.uvm.edu/AIM/default.html

AIM (Apple Information Manager) is a collaborative Extension and research effort of the Universities of Vermont, Maine, New Hampshire, Massachusetts, Connecticut, and Rhode Island. Excellent weather resources and IPM decision-making tools for New England orchardists. Archived and current Extension and research newsletters and publications. Grower and Extension contacts. Searchable.

http://pmo.umext.maine.edu/apple/PestGuidePDF/98neapmgdirectory.htm

1998-99 New England Apple Pest Management Guide.

http://www.caf.wvu.edu/kearneysville

Kearneysville Tree Fruit Research and Education Center, West Virginia University. Keys to pest identification, with great photographic images of insects and disease symptoms. Lots of useful information for fruit growers in the mid-Atlantic region. Online newsletters and publications, archived. Links.

http://www.caf.wvu.edu/kearneysville/fruitloop.html

The Mid-Atlantic Regional Fruit Loop, a cooperative effort bringing together information from fruit professionals in Maryland, Michigan, New Jersey, New York, North Carolina, Pennsylvania, Virginia, W. Virginia, and USDA/ARS.

http://www.virtualorchard.net

The Virtual Orchard is a forum for research and Extension projects dealing with sustainable commercial apple production and marketing issues. Includes up-to-date news on issues affecting apple growers. Searchable.

http://fruitsandnuts.ucdavis.edu/app2.html

Links to all sorts of apple information.

http://axp.ipm.ucdavis.edu/PMG/r4100211.html

University of California Statewide IPM Project. UC Pest Management Guidelines—Apple.

http://www.msue.msu.edu/vanburen/organasp.htm

Organic Apple Spray Program. Michigan State University Extension's suggested spray schedule for organic apple production in Michigan. Written by Mark Longstroth, District Extension Horticulture and Marketing Agent.

http://www.caf.wvu.edu/kearneysville/organic-apple.html

Disease Management Guidelines for Organic Apple Production in Ohio, by OSU's Michael Ellis. This Extension publication is exactly what it says in the title – guidelines (not a systematic, calendar spray approach as in the MSU publication above) and only for diseases, not insects. You can order a hard copy free of charge (see above under Books).

Other Projects and Organizations:

Casey County Apple Project
Tommy Yankey
Casey County Extension Office
P.O. Box I, Hwy 127 South
Liberty, KY 42539
e-mail: tyankey@ca.uky.edu

A group of producers in several counties will take part in a study of the feasibility of organic apple production compared to IPM production. They will also look at the economics of intercropping in rows of newly established orchards. Trees were planted in Fall, 1995.

Core Values Northeast
Mothers & Others
40 West 20th Street, 9th floor
New York, NY 10011-4211
888-326-4636
e-mail: mothers@mothers.org
http://www.igc.apc.org/mothers

Plants: (disease-resistant apple cultivars)

Raintree Nursery
391 Butts Rd.
Morton, WA 98356
360-496-6400
www.raintreenursery.com

Rocky Meadow Orchard & Nursery
360 Rocky Meadow Rd. NW
New Salisbury, IN 47161
812-347-2213

Stark Bros.
Hwy. 54 West
Louisiana, MO 63353
573-754-5511
www.starkbros.com

St. Lawrence Nurseries
325 State Hwy 345
Potsdam, NY 13676-3515
315-265-6739
www.sln.potsdam.ny.us

Supplies: (Pheromone traps, beneficial insects, pesticides, etc.)

Engelhard Corporation
101 Wood Avenue
Iselin, NJ 08830
e-mail: john.mosko@engelhard.com

Gempler's
P.O. Box 270
Belleville, WI 53508
800-332-6744
www.gemplers.com

Great Lakes IPM
10220 Church Rd.
Vestaburg, MI 48891-9746
517-268-5693
www.greatlakesipm.com

Harmony Farm Supply
P.O. BOX 460
Graton, CA 95444
707-823-9125

IPM Technologies
4134 N. Vancouver Ave.
Suite 105

Portland, OR 97217
888-476-8727
www.ipmtech.com

Peaceful Valley Farm Supply
P.O. Box 2209
Grass Valley, CA 95945
916-272-4769
www.groworganic.com

Rincon-Vitova Insectaries, Inc.
P.O. Box 1555
Ventura, CA 93002-1555
805-643-5407
www.rinconvitova.com

Superior Ag Products
700 S. 92nd Ave.
Yakima, WA 98908-9302
509-965-7829

By Richard Earles, Guy Ames, Radhika Balasubrahmanyam, and Holly Born, NCAT Agriculture Specialists

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Appendix 2: Disease Resistant Apple Varieties

By Guy Ames, ATTRA Technical Specialist

There are several important considerations to keep in mind when using the following chart.

First, disease resistance is rarely absolute, and it is usually described in relative terms (e.g., susceptible, moderately susceptible, resistant, etc.). To further complicate matters, different researchers use different rating scales to describe disease resistance/susceptibility. For example, some published studies use a numerical scale (usually 1–10) while others use more absolute measurements, such as the number of fire blight lesions on a leaf or the centimeters of shoot tissue affected by fire blight. For the purpose of compiling this chart, it was necessary to convert these different systems into a uniform rating scale. I alert the reader to this fact, and apologize to the researchers for any liberties I have taken with their work.

Second, the occurrence of disease is dependent on three factors (the "disease triangle"): a susceptible host; a suitable environment; and the presence of the disease-causing pathogen. For example, alternaria leaf blotch is a disease that appears to be limited to parts of the Southeast United States. Other regions either do not have the pathogen, or present an environment unsuitable to the disease. As another example, cedar apple rust does not occur where the Eastern red cedar does not grow, for the pathogen is dependent on the red cedar to complete its life cycle. Cedar apple rust resistance is therefore unimportant in the whole of the Western U.S..

Also note, as a corollary to the disease triangle notion, that the environment can affect the expression of a disease in terms of its virulence. In other words, mildew in Virginia may be much worse than mildew in Kansas, though mildew could be found on apple trees in both places. This is occasionally reflected in the following chart by the occurrence of conflicting entries for the same disease on the same cultivar. For an example, see the entry for fire blight on Jonafree. (Differing environmental factors are probably *not* responsible for the discrepancies between some entries for 'Priscilla'. See note below chart.)

The numbers behind some entries refer to the published source of that information, cited below in the References section. Where entries are not accompanied by a reference number, the entry is based upon my own or other apple growers' observations. (Much of the information for white rot and black rot was originally compiled from growers and researchers by Brenda Olcott-Reid.) I believe that most of these observations will hold true for most growers under most conditions, but it is possible that what a grower took to be "resistance" was in reality a simple "escape".

On the other hand, if an unreferenced entry reads "s" or "vs" ("susceptible" or "very susceptible"), the grower probably observed a bona fide infection—it's hard to say a cultivar has any resistance to scab if you're looking at apples warped and cracked by scab. In other words, if a "negative" is a lack of disease and a "positive" is an observation of disease, a false negative is more likely than a false positive.

Where there is a blank for a cultivar under a specific disease, there was not sufficient information to make an entry.

Disease Key:
ALB = alternaria leaf blotch
CAR = cedar apple rust
FB = fire blight
MIL = mildew
SCAB = scab
BR = black rot/bitter rot
WR = white rot

Resistance Rating Key:*
vr = very resistant
r = resistant
mr = moderately resistant
ms = moderately susceptible
s = susceptible
vs = very susceptible

***r/mr**: may show symptoms, but probably will not require sprays.
ms: sprays may be necessary in bad conditions.
s: sprays probably necessary where disease is present.
vs: sprays necessary where disease is known to be prevalent.

Disease Resistant Apple Varieties

Variety	ALB	CAR	FB	MIL	SCAB	BR	WR
Akane	mr (1)	vr (11)	mr (7)	mr	ms	r	mr
Anna		ms	r	s	mr		s
Arkansas Black		r	mr	r	ms	r	r
Arkansaw		r	r	r	r	r	mr
Ashmeads Kernel		mr	vr	r (6)	ms	r	mr
Astrachan			r (4)				
Baldwin			s (4)		s (6)		
Barry			vs (4)				
Beacon			ms (4)				
Ben Davis			r (4)				
Beverly Hills			s (4)				
Black Gilliflower			vs (4)				
Blairmont		s	vr	r	mr	r	mr
Blushing Golden		r (11)	ms (7)	r (6)	s (6)		
Braeburn	mr (1)	vs	s	vs	s		
Bramley's Seedling		s	r	r (6)	r (6)	r	mr
Britegold		s (10)	r (12)	r (10)	vr (10)		
Brown Russet				r (6)	r (6)		mr
Buckley Giant			vs (4)	r (6)	r (6)		
Chehalis		s	mr	mr	r	mr	s
Cox's Orange			ms (4)				
Crimson Beauty			vr (4)				
Daniels		vr	r	mr	ms	r	mr
Dayton		ms	mr	mr	vr (9)	ms	mr
Delcon			r (4)				
Delicious		r (8)	vr (4)				
Delicious, Red	s (1)			r (6)	s (6)		
Detroit Red			r (4)				
Discovery				vr (6)	s (6)		
Dorsett Golden			ms (4)				
Ein Shemer			s (4)				
Empire	ms (1)	r (8)	r (4)	s (8)	s (6)	s	
Enterprise		r (10)	r (10)	r (10)	vr (10)	r	

Disease Resistant Apple Varieties

Variety	ALB	CAR	FB	MIL	SCAB	BR	WR
Fameuse			vr (4)		s (6)		
Firmgold	ms (1)						
Florina		r	r		vr (5)	mr	
Freedom		vr (3)	mr (3)	mr (2)	vr (10)	s	s
Fuji		r (11)	vs (7)	r	s (6)	r	mr
Fuji, Red			ms (7)				
Fyan			s (4)				
Gala		ms	ms	mr	s	s	ms
Gala, Fulford	mr (1)		ms (7)				
Gala, Red	ms (1)						
Gala, Royal	r (1)		ms (7)				
Gala, Scarlet			mr (7)				
Gala, Spur (Go-Red)			vs (7)				
Gala, Stark			ms (7)	r (6)	s (6)		
Ginger Gold	r (1)						
Golden Delicious	r (1)	vs (8)	vr (4)	r (6)	s (8)		
Goldrush		vs (10)	r (10)	r (10)	vr (10)		
Golden Russet		s (11)	ms	r	r	s	s
Grandspur	r (1)						
Granny Smith	r (1)	vr (11)			s (6)		
Gravenstein			vs (4)	r (6)	vs (6)		
Grimes			r (4)				
Grove			r (4)	r (6)			
Haralson		mr	r (4)		s		mr
Hawaii		r	vr	mr	s (6)	ms	ms
Holly				vr (6)	s (6)		
Honeygold				r (6)	s (6)		
Horse			s (4)				
Hudsons Golden Gem		s	r	r (6)	r (6)	r	mr
Idared			vs (4)	s (6)			
Irish Peach			r (4)	r	r		ms
James Grieve			vs (4)				
Jefferis		s	r	mr	r		s
Jerseymac		vr (11)	s	vs (6)	vs (6)		
Jonadel			r (4)				
Jonafree		s (3)	mr(3)vs(7)	r (2)	vr (10)	r	mr
Jonagold	r (1)	s	ms (7)	s	s		
Jonagram			s (4)				
Jon-A-Red	ms (1)						
Jonathan		s (11)	vs (4)				
Jonathan,Double Red	mr (1)						
Kidd's Orange Red			r (4)				
King David		r	ms	r	r	ms	mr
King Luscious			s (4)				
Lawspur Rome	mr (1)						
Liberty		vr (3)	r (3)	s(2) r(6,7)	vr (6)	mr (8), s	mr
Limbertwig		r	mr	r	mr	r	mr
Lodi			vs (4)		s (6)		

Disease Resistant Apple Varieties

Variety	ALB	CAR	FB	MIL	SCAB	BR	WR
Loriglo	mr (1)						
Lurared	ms (1)						
Lysgolden	r (1)						
MacFree		vr (3)	mr (3)	s (2)	vr (8)	s (8)	mr
Macoun			mr (4)	s (6)	s (6)		
Maiden Blush			r (4)				
Maigold				r (6)	s (6)		
Mammoth Black Twig			ms (4)				
McIntosh		vr (8)	r (4) s (8)	s (2)			
McShay		vr	ms	mr (9)	vr (9)		s
Melba			r (4)	r (6)			
Melrose		vr	r (4)	s (6)	s	r	mr
Moira		r (10)		s (10)	vr (10)		
Mollies Delicious			r (4)		s (6)		
Mother		ms		r (6)	r (6)		
Murray		r (10)	r (10)	r (10)	vr (10)		
Mutsu	mr (1)	s(8)vs(11)	s (4)	vr(6)vs(8)	vs (8)		
Nittany	r (1)						
Northern Spy		s (8)	vs (4)	s (8)	s (8)		
Nova Easygro		vr (3)	mr (3)	r (2)	vr (8)	mr (8)	
Novamac		r	r	ms (10)	vr (10)	mr	mr
Novaspy					vr (13)		
Nured McIntosh	ms (1)						
Nu Red Rome	r (1)						
Orleans		r	mr	mr	mr		ms
Ozark Gold	r (1)		mr (7)	r (6)			
Paragon			r (4)				
Pink Pearl			vs (4)				
Priam					vr (9)		
Prima		vs (8)	mr (3)	r (2) s (8)	vr (8)	r	s
Priscilla*		r (10) s (3)	vr (3)	s (2) r (6)	vr (6)	r (8)	s
Raritan		vr (11)					
Redcort		vr (11)					
Redfree		vr (3)	mr (3)	ms (2) mr	vr (9)	s	ms
Red Fuji	ms (1)						
Red June			s (4)				
Red Yorking	ms (1)						
Richelieu					vr (13)		
Rouville					vr (13)		
Roxbury Russet		r	ms (4)	r	mr		ms
Shamrock		vr (11)					
Sinta		s (11)		r (6)	s (6)		
Sir Prize		s (3)	ms (3)	s (6)	vr (6)	r (8)	
Smokehouse			r (4)				
Smoothee	r (1)	s (3)	mr (3)	s (2)			
Snow			r (4)				
Spartan		r (8)	r (4)	r (8)	ms (6)		
Spencer			vr (4)		s (6)		
Spigold		vs (11)	vr (4)	s (6)			

Disease Resistant Apple Varieties

Variety	ALB	CAR	FB	MIL	SCAB	BR	WR
Spitzenberg, Red			s (4)		s (6)		
Stark Earliest			s (4)				
Stark Splendor				vr (6)	s (6)		
Stark Summerglo				r (6)	s (6)		
Stark Summer Treat				r (6)			
Starkspur Winesap	r (1)						
Stayman	r (1)	r	mr (4)	ms	ms	r	ms
St. Edmunds Pippin		r	mr	r	mr	r	ms
Steele's Red			vs (4)				
Stirling				r (6)	r (6)		
Summer Pearmain			ms (4)				
Summer Rambo			s (4)				
Summer Treat	r (1)						
Tangier				vr (6)			
Thompkins King		ms	s (4)	mr,ms(6)	mr		
Toko				r (6)			
Trent		r (10)	r (10)	ms (10)	vr (10)		
Turley			r (4)				
Twenty Ounce			vs (4)				
Tydeman's Early				r (6)	r (6)		
Tydeman's Red			vs (4)				
Ultragold	r (1)						
Wagener			s (4)				
Wayne			s (4)				
Wellington			vr (4)				
Whetstone			ms (4)				
Williams Pride		vr (3)	r (3)	ms (2)	vr (9)	r	mr
Winesap	r (1)		r (4)				
Wolf River			vs (4)	r (6)	r (6)		
Wynooche		r	ms	mr	vr		mr
Yates		r	r			r	r
Yellow Belleflower			r (4)				
Yellow Delicious	r (1)						
Yellow Newtown			ms (4)				
Yellow Transparent			vs (4)				
Yorking			s (4)				

*There may be two "Priscillas" in circulation. Descriptions of disease resistance and fruit characteristics vary widely among researchers and growers, adding credibility to the notion that somehow two genetically distinct trees are both going by the name Priscilla.

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