ATTRA Sustainable Agriculture
A program of the National Center for Appropriate Technology • 800-346-9140 • ATTRA.NCAT.ORG

Tree Fruits: Organic Production Overview

By Guy K. Ames, George Kuepper, and Ann Baier
NCAT Agriculture Specialists
Updated February 2023 by Guy K. Ames

IP028

Contents

This publication is produced by the National Center for Appropriate Technology through the ATTRA Sustainable Agriculture program, under a cooperative agreement with USDA Rural Development. ATTRA.NCAT.ORG.

This guide is an overview of issues relevant to commercial organic production of temperate-zone fruiting trees and bushes and, to a lesser extent, tree nuts. It includes discussions of marketing and economics, orchard design, and cultural considerations, including crop varieties, site selection, site preparation, soil fertility, weed control, and pest management (insects, diseases, and vertebrates). It raises questions for the grower to consider in making decisions about orchard and enterprise design. Lists of electronic and print resources offer further, more detailed, information.

Photo: Guy Ames, NCAT

Introduction

This publication focuses on producing and marketing organic fruits and nuts, highlighting a systems approach to orchard production and farm management. Not intended as a comprehensive production guide for individual fruit crops, this publication introduces key production issues that merit consideration for any specific crop or production region. As noted below, ATTRA has other publications for specific fruit and nut crops. General information on cultural practices for fruit production (choosing varieties, spacing, pruning, training, irrigating, harvesting, postharvest handling, etc.) is relevant to both organic and conventionally managed operations, and it is widely available from the Cooperative Extension Service, nurseries, and in horticulture literature.

A Note about Organic Standards

This publication includes references to the organic standards authorized by the USDA's National Organic Program, ams.usda.gov/nop. Organic producers should verify with the appropriate certification bodies that their practices and any materials they intend to use are compliant with applicable standards for their intended markets. This is especially true if those markets are international, where there may be additional production and labeling requirements.

Organic Fruit Production

Organic production is defined by USDA's National Organic Program (NOP) as "A production system that is managed…to respond to site-specific conditions by integrating cultural, biological, and mechanical practices that foster cycling of resources, promote ecological balance, and conserve biodiversity."

Organic fruit production involves more than simply excluding synthetic pesticides and fertilizers. Benign neglect does not meet NOP standards for production. Organic agriculture is an integrated approach to active and observant management of a farming system. It begins with good soil management for nutrient cycling, productivity, and tilth. It involves an integrated, preventative approach to pest management in order to protect the health and productivity of the orchard.

Related ATTRA Publications
ATTRA.NCAT.ORG

Apples: Organic Production Guide

Pawpaw – A Tropical Fruit for Temperate Climates

Peaches: Organic and Low-Spray Production

Pears: Organic Production

Soils and Sites for Organic Orchards and Vineyards

Marketing and Economic Considerations

To plan for economically successful enterprises, farmers must design their fruit production systems to match their marketing strategies. Good fruit production alone does not lead to a successful enterprise. Profitability depends on a combination of production volume, quality, size, and a reliable marketing strategy. Marketing channels range from direct markets to wholesale shippers. Growers must understand what each of their customers wants and be prepared to meet the expectations of the markets they intend to reach. For example, at farmers markets, customers seek good-tasting fruit at or near the peak of ripeness for prompt consumption, but supermarket distributors demand that fruit be uniform and shippable. It is important to market in an appropriate niche: one where the produce of your operation can consistently meet the buyers' expectations of volume, quality, and timing.

At farmers markets, customers seek good-tasting fruit at or near the peak of ripeness. Supermarkets want uniform and "perfect" fruit. Photo: Guy Ames, NCAT

Premium pricing can be critical to the viability of organic fruit operations because production costs are often higher than those for conventional orchards. Organic pest control, particularly labor costs for hand thinning and weed control, is generally more expensive than conventional practices. Yield and quality can vary widely, depending on the growing season and management practices. In the past, it may have been true that organic yields and pack-out rates (the percent of marketable fruit) were lower in conventional production. Today, however, those differences have narrowed, and yields in some organic production systems can match or exceed those of conventional systems. To achieve good yields, organic growers must be prepared to develop innovative production and marketing strategies. Many commercial organic fruit producers, especially family-scale farmers, minimize waste and losses of potential revenue by processing (drying, preserving, or juicing) fruit considered unsuitable for the fresh market. See ATTRA's publication *Adding Value to Farm Products: An Overview.*

Having organic certification increases marketing flexibility. An organic certificate provides the option, but not the obligation, to use the organic claim. When it is advantageous, organic produce can be sold as conventional, but never vice-versa.

For more information on marketing, consult the ATTRA publications *Evaluating a Farming Enterprise* and *Direct Marketing.*

Climate Change and Organic Fruit Production

Climate change is presenting a new array of challenges to the growers of perennial fruits and nuts. More frequent extreme weather events like floods, hail, and droughts are pushing many growers to the brink of insolvency. Almond orchards in California are being bulldozed out for lack of affordable water. Apple growers in New England are finding more and more fungicide sprays necessary to combat increasing disease pressure fostered by violent storms and/or unusually long-duration rainy periods. And, almost everywhere across the globe, warmer winters are leading to earlier-than-normal bloom and subsequent crop loss when spring frosts hit.

The relatively higher establishment costs of perennial crops relative to annual crops (trees vs. seeds), as well as the longer interval between initial investment and profitable returns (time between planting and harvest) have always demanded long-term planning based on a given region's climate. But when the climate becomes unstable, such planning is problematic, and growers may have to build in an economic cushion and otherwise account for increased risk of crop losses.

Organic growers face an additional trial: they are more likely to be reliant on cultural controls for disease control, like pruning and cultivar choice, rather than on sprays of fungicides and bactericides. If the environment becomes more conducive to plant disease, as it appears to be doing, cultural controls could be overwhelmed, and organic growers won't have the broad arsenal of fungicides and bactericides that conventional growers have. (To be clear, even conventional growers will face increasing costs for disease control.)

ATTRA's *Climate Change and Perennial Fruit and Nut Production* provides some ideas to meet the challenges of climate change. For instance, better soil that's high in organic matter can ameliorate both extremes of water—too little or too much. Increasing crop diversity—more varieties and more species—could also reduce the risks of large crop losses attendant with monocultures, but note that increasing diversity will cost more money, too.

We are in largely uncharted waters. Growers will have to be nimble, creative, and resilient to find a course to keep profitably growing perennial fruits and nuts.

Planning and Planting an Organic Orchard

Cultural practices in fruit production begin with selection of an appropriate site, fruit crop, rootstock, and fruit variety, followed by site preparation (tillage and pre-plant soil amendments) and orchard layout (tree and row spacing). These considerations will largely determine the productivity, health, and efficiency of operations in your orchard over the long term, and they cannot easily be changed once the orchard is established. See the ATTRA publication *Soils and Sites for Organic Orchards and Vineyards* for more planning guidance. If you are managing an existing orchard, you will continually need to take stock of its assets and limitations in relation to current markets and either work within those limits or make plans for some degree of orchard renewal. If you are considering purchasing an existing orchard, ask the owners about their financial history (production costs and sales records), and research the market to assess the economic feasibility of continuing with the business as it is currently practiced. Once you have made the most realistic cost estimates possible, you can develop a plan to adjust the production system, revise the marketing plan, or walk away while you still have your shirt.

Williams Pride, disease-resistant apple variety. Photo: Guy Ames, NCAT

Longer Wait Before Monetary Returns

A very important difference between the business of perennial fruit crops and other cropping systems is the time between initial investments and the beginning of monetary returns on those investments. Depending on the orchard crop, the time interval between planting and first harvest is likely to be greater than two years, and the time before profitable returns could be three, four, or even five or more years. Remember, you don't just plant the trees and wait for the fruit to be ready. Rather, you have to train, prune, irrigate, fertilize, protect from pests, and otherwise care for the trees whether or not they are of bearing age.

If you don't have deep pockets, you will have to educate your investors regarding this economic reality. In fact, outside of established fruit-growing regions, lenders unfamiliar with orchard crops may be reluctant to invest in such long-term ventures.

Orchard ladders. Photo: Guy Ames, NCAT

Specialized Knowledge, Specialized Equipment

Every farming enterprise undoubtedly has its own jargon, equipment needs, specialized knowledge, and other peculiarities. However true this may be, it is arguably even more so for tree fruits. Pruning and training systems—some of them quite complicated, even arcane—require an underlying knowledge of plant physiology. An understanding of pollination and fruit set is fundamentally necessary. Chilling hours, clonal root stocks, fruit thinning, trellising systems, and fruit storage requirements are just a few of the other topics a fruit grower will have to be well versed in. It would be a huge advantage to have actual in-orchard experience before starting your own orchard. If you don't have seasons-long experience, a lot of education, including field days and hands-on workshops, is strongly recommended.

Likewise, there are a lot of tools and infrastructure specific to growing orchard crops. Special orchard ladders, high-powered sprayers capable of spraying tall trees, and various pruning tools, including pneumatic pruners, grafting knives, controlled atmosphere storage units, and multi-wire trellis systems, are just some of the things an orchard manager may have to acquire and understand. Again, actual experience with these things would be best, if possible.

Planting an Organic Orchard

Site Selection

Fruit trees, like most crops, respond to good soil with vigor and productivity. Trees can successfully produce economic yields on hillsides, rocky soils, and other sites not suitable for frequent tillage. Look carefully at your site and take stock of its soil, slope and aspect, water infiltration and drainage, frost patterns, maximum and minimum temperatures, length of growing season, distribution of annual precipitation, availability of water for irrigation, proximity of the water table, and wind and air circulation patterns. Most of these are beyond your control, and your planting plan must suit the natural conditions of the site. Although farmers may be able to improve the soil over time, they cannot change the subsoil layers, influence the prevailing wind, or modify temperatures to any significant extent.

All the factors regarding site suitability for

conventional fruit plantings apply—even more so—to organic operations. While conventional growers may fall back on chemical fertilizers and pesticides to compensate for some poor site decisions, organic growers cannot. Good drainage and air circulation are essential for disease control. The presence of certain weeds and forage species is of particular concern to the organic grower. Bermuda grass, Johnson grass, quack grass, and several other pernicious species can be serious problems to fruit growers and are difficult to control with organic methods once an orchard is established.

An assessment of physical and environmental factors will help the grower determine whether a crop can be grown easily, marginally, or not at all. Someone with a home orchard may consider it worthwhile to cover a lemon tree before each anticipated frost, or to nurse a few apricot trees through Midwestern winters in order to savor the delicious fruits two seasons out of seven, but these would likely not be viable commercial enterprises. However, stretching the limits of production within reason can be worthwhile under certain circumstances. For example, subtropical fruits grown in the coastal valleys of California bring a premium for their freshness and novelty, offsetting the expense of the extra care they require. Depending on the crop, harvesting either early or late in the season can also provide a market advantage. Although California's San Joaquin Valley is not known for apple production, its warmer spring and summer temperatures can bring the crop to maturity a few weeks ahead of coastal producers. The price premium for first-of-the-season organic fresh-market apples may offset the overall lower crop yields. On the other hand, fruit grown in its primary growing region may be more difficult to distinguish from the rest of the fruit in the market, and so lose its competitive edge.

Crop Species Selection

Clearly, the first decision is what species to plant. Is a tree orchard the best use of your land and talents? Or are your site and marketing plan better suited for a somewhat shorter-term investment in smaller plants, such as blueberries, caneberries (raspberries, boysenberries, olallieberries, other blackberry varieties), grapes, kiwi, or even strawberries? If you are sure that you are willing to manage tree fruits and nuts, will your focus be to produce almonds, apples, apricots, avocados, cherries, figs, grapefruit, jujubes, lemons, oranges, pawpaws, peaches, pecans, pears, persimmons, plums, pluots, or zapotes?

Pragmatism is critical in crop and variety selection. The fruit grower must take into account not only factors of yield, productivity, quality, and flavor, but also of marketability. Diversification of varieties and marketing channels is a prudent strategy. While one farm in California may receive a good return for the fruit from one lone jujube tree, there is no assurance that such a profit can be scaled up to an extensive orchard of specialty fruits. Conclusions: while the jujube is a tasty and unusual fruit, and the value of fruit from one tree may be substantive, the regional market for this novelty would not accommodate production from 200 trees.

Because fruit trees are perennial and represent a considerable investment of both time and money, it is important to start by planting your orchard with the optimum varieties for your location and intended markets. Research on the front end can pay the grower back many times over. Information on species and varieties is available from ATTRA, Cooperative Extension, nurseries, and other local growers. Many land-grant universities have field stations where they have planted many varieties of fruit trees and gathered data and observations over several years. A visit to such a site can provide you with the invaluable opportunity to see the trees growing, talk with the manager of the experiment station about production challenges such as pests and diseases, and even taste the fruit.

Because fruit trees are perennial and represent a considerable investment of both time and money, it is important to start by planting your orchard with the optimum varieties for your location and intended markets.

Magness European-type pear. Photo: Guy Ames, NCAT

The availability of production supplies and markets in your region can be a critical factor in crop selection. Being the only one growing a certain fruit may provide you with a local marketing niche; however, the value of readily available supplies and services should not be underestimated. While some supplies can be easily and cost-effectively shipped by mail, others cannot. Pest-management materials such as codling moth pheromone traps can be efficiently shipped from a distant supply company. But how far do you have to drive to purchase boxes and bulky packaging supplies? How far to cold storage, a packing house, distributor, processor, or transportation terminal? Driving several hours to purchase appropriate boxes or to deliver fruit to a broker's cooler can make an otherwise viable enterprise unprofitable.

Asian pear packing line. Photo: Jeff Boullioun

East is East and West is West…

For the purposes of organic fruit production, it is extremely important to understand why more than 90% of the United States' fresh-market organic apples and organic sweet cherries are grown in the state of Washington. And the same goes for organic peaches and plums in California. Here is the key: without irrigation, those fruit-growing regions are essentially deserts and, as such, do not have the environment to foster anything like the disease and (to a lesser extent) insect problems that are found in the East.

There is an imaginary boundary called "the tree line" that runs north and south from roughly Fargo, North Dakota, to Fort Worth, Texas. East of that line, there is enough rainfall to support tree growth. West of that line, there is not, and grassland becomes the dominant natural ecosystem. It is not the trees, per se, that are the problem—though some insect pests (like plum curculio and trunk borers) spend part of their life cycle in the woods—it's the amount of rainfall that negatively impacts organic fruit production in the East.

Multiple diseases on an apple. Photo: Guy Ames, NCAT

Almost all the major fruit pathogens require rain to spread and infect, and, in the East, there are diseases (e.g., sooty blotch on apples) and insects (e.g., plum curculio on peaches) that are literally unknown in the West. And where a disease or pest problem can be found in both East and West, you can be certain that such disease or insect pressure will be much higher in the East. This is true to the degree that practically all organic tree fruit for the national market is grown in the West. Conventional growers in the East use synthetic fungicides and insecticides to level the playing field, but there is, as yet, nothing equivalent in the organic arsenal of pesticides. (Growing in a high tunnel is the closest thing eastern growers have.)

Consequently, the aspiring organic tree fruit grower in the East must cultivate and educate a local clientele and diversify their offerings. If they want to grow apples, they must start with the most disease-resistant cultivars available, which are not the hottest cultivars in the marketplace. If they want to grow peaches…they shouldn't. Fire blight-resistant pears have worked for some eastern growers. An innovative grower and clever marketer could add tree crops like pawpaws and jujubes to their orchards. And bush and cane fruits (e.g., blueberries and blackberries) aren't nearly as hard to grow organically in the East as are the tree fruits. However, if you're thinking "big," go west (but make sure you have an irrigation source!).

Variety and Rootstock Selection

Once the question of crop species is settled, the next decision is what variety (or combination of varieties) to plant. Considerations include, but are not limited to, the following:

- harvest season: early, mid, or late season, or a combination of these to achieve a more continuous supply or to ensure a crop during early or late marketing windows
- adaptability to the region: cold hardiness, temperature ranges for optimal growth, requirements for soil fertility or pH
- chill requirements for fruit set and flavor
- water requirements: need for irrigation or protection from waterlogging
- stature: dwarf, semi-dwarf, or standard
- resistance to diseases and pests
- marketability: color, flavor, nutritional value, storage requirements, shipping ability, uniformity, shelf life—any characteristics that define quality for your customer
- proximity to appropriate markets

You can select for desired characteristics, especially in grafted trees, with a combination of varieties of rootstock and fruiting wood.

Sources of Planting Stock

It is important to get clean planting stock. Buying from reputable nurseries that provide stock certified by state inspectors to be free of diseases and insect pests is best. Organic planting stock is required, if commercially available, for certified organic fruit production. If organic planting stock is not available, organic growers must document their search for organic stock and its lack of commercial availability. Most certifiers interpret the organic standards as requiring organic management of non-organic planting stock for at least 12 months before harvesting a crop that is to be sold as certified organic. With newly planted tree crops, this is a non-issue, since they generally grow for at least three years before producing a marketable crop.

Type and Size of Planting Stock

Tree size determines the spacing, number of trees per acre, training system, years to bearing, and timing of economic return. Orchard design should reflect the grower's production and cash-flow goals. Smaller trees have higher initial planting costs because more trees are needed to achieve density. Smaller trees simplify many field operations, including pruning, grafting, thinning, pest management, and harvest. Efficiency and safety are greater when most operations can be accomplished from the ground, as opposed to using ladders or by climbing. Weeds are less of a problem in the shade of a densely planted orchard.

Size-controlling rootstocks have been developed for apples and sweet cherries, and such rootstocks are being developed for other tree fruits but with varying degrees of success. Despite the exaggerated claims of home-scale nursery catalogs and the tags on fruit trees at big-box stores, commercial growers should cast a skeptical eye on claims of dwarf this-or-that fruit tree, especially before laying out their orchard based on such claims. For instance, the research with dwarfing peach rootstocks resulted in smaller trees…with poor cropping, nematode susceptibility, and other problems. Growers desiring smaller trees for a particular cropping system can often accomplish that goal with appropriate training and pruning.

Depending on the species and variety, bareroot trees are often the most practical form of planting stock to ship and the most economical to purchase. This is a good option for deciduous trees. Other varieties, such as citrus, must be purchased in containers. Given the option of different sizes of bareroot trees, some walnut growers say that investing in a 1-inch tree rather than a 3/4-inch tree is worthwhile because larger trees grow

Tree size determines the spacing, number of trees per acre, training system, years to bearing, and timing of economic return. Orchard design should reflect the grower's production and cash-flow goals.

Dwarf apple orchard. Photo: Guy Ames, NCAT

more vigorously. An experienced apple grower who produces without irrigation beyond the first year, however, stated his preference for 5/8-inch bareroot trees, which have a good balance of roots and are neither too big nor too small.

Disease and Pest Resistance

Genetic resistance refers to inheritable traits that enable a plant to inhibit disease and resist pest damage. A very important control measure for organic growers is to choose cultivars that are resistant to the pests—especially the diseases—most prevalent in their areas. In some cases, such as that of bacterial spot in peaches, cultivar resistance is the best or only control for a particular disease. A cultivar may be quite resistant to one disease but still susceptible to another. Gold Rush apples, for instance, are very resistant to scab but very susceptible to cedar-apple rust. Remember that a planting stock resistant to a particular pest provides only relative resistance, not absolute immunity. Meanwhile, a moderately resistant or tolerant variety may show symptoms of the disease but exhibit little to no reduction in yield.

A very important control measure for organic growers is to choose cultivars that are resistant to the pests—especially the diseases—most prevalent in their areas.

Disease resistance must be weighed against other advantages. For example, walnut growers in the coastal regions of California have lost large numbers of trees in recent years to "black line," a fungal disease for which there is no treatment, only resistance. Payne variety is susceptible, and Chandler is highly resistant to this disease. (Some say that Chandler also appears to suffer lower damage levels from codling moth and walnut husk fly, the other common walnut pests in the region.) A trade-off is that Paynes mature sooner and can be harvested earlier in the fall, whereas Chandlers come in at least a month later, when early rains can hinder harvest operations and make field preparations for planting a winter cover crop difficult or impossible.

Although no fruit trees are resistant to insects that damage their fruit, it is possible to find stock that is resistant to insects that feed on other parts of the plant—woolly aphid-resistant apple rootstocks and nematode-resistant peach rootstocks, for example. As important as this resistance is, there is no cultivar of any fruit species with multiple-insect-pest resistance; therefore, an integrated pest management plan is necessary to protect fruit plants from a complex of several pest species. It will be important to identify the most troublesome pests for your crop and region in terms of frequency of incidence, severity of damage, cost of control, and economic consequences of the damage. Then, seek out varieties that are resistant to those key pests and take into account any trade-offs you may make with other desirable characteristics, including seasonality, productivity, and flavor. Substantial crop- and variety-specific information on pest and disease resistance is available on the University of California IPM project website and from other university pomology departments. Be sure to check with local suppliers of planting stock and talk with other growers in your area about what has worked best for them.

Orchard Layout and Design

Orchard layout influences the long-term health of the trees and the ease of field operations such as pruning, irrigation, fertilization, and weed and pest management. Everything is related: the decisions you make about the space between rows and between trees in the row will have an impact on everything from disease management to harvest operations. While the specific spacing and training of trees will largely depend on the species, the following questions offer general considerations that will save time, resources, and expenses throughout the life of the orchard.

- What is the lay of the land? Which way does the water run? What is the angle of the sun during different seasons? How will these affect the movement of both water and air and, in turn, temperature and humidity levels, crop ripening, and incidence of diseases and pests? Do the rows need to be planted on the contour for soil conservation or to capture limited seasonal moisture? Or should they be sloped to drain excess moisture? Given the degree of slope, which direction will provide the greatest safety for operating equipment and ease of harvesting?
- What are the diseases and pests that affect this crop in this region? What are their life cycles? Alternate hosts? Natural enemies? What conditions favor their growth and severity? What design strategies might promote or reduce these conditions? Would a certain orientation of the rows provide better exposure to the sun or better air circulation? Will you rely on seasonal pruning to maintain an open canopy to increase air flow through the foliage and sun to the fruit?

- What equipment will you use for field operations? Consider all possible tasks, including planting, mowing (or incorporating orchard floor vegetation), cultivation, pruning, irrigation, application of materials for pest management, and fruit harvest. Be sure that your row spacing is adequate to allow entry and maneuverability of any tractor, trailer, spray equipment, string trimmer, wagon, wheelbarrow, or hand cart that you plan to use.
- What crop density do you seek? How soon after planting? The decision will depend on the species and stature of your trees, the cost of purchasing and planting them, the years to maturity, the prevalence of weeds, and other considerations. Using close in-row spacing or double rows of trees may complicate weeding in the first year or two, but, thereafter, shading will greatly reduce the need for weeding the inter-row. Some farmers plant slower-growing trees (such as walnuts) using closer spacing, then remove every other tree when they reach a certain maturity. The estimated benefits of earlier harvests must be considered against the costs of planting, managing, and eventually removing the trees. Alternatively, annual crops can be grown between immature orchard trees.

Site Preparation

Important considerations in site preparation include alleviating soil compaction, enhancing fertility, adjusting soil pH, and managing weeds, pests, and diseases. Attention to the details of site preparation can help reduce weed and disease problems and assure a vital planting through soil improvement. What needs to be done depends on the previous use of the land, including crops grown, current vegetation, and the presence of pests and diseases. Many growers rip or chisel the soil to loosen layers of compaction before they plant a new orchard, since deep tillage will be disruptive once the trees are established.

Before establishing an orchard, it is important to adjust the soil pH to best suit the crop you've selected. Soil tests can assess current soil conditions, including pH, mineral levels, and their relative proportions. Traditionally, pH has been adjusted through applications of lime (to raise the pH) or sulfur (to lower pH). Most fruit plants perform best around pH 6.5, although they tolerate a pH range between 5.5 and 7.2. Blueberries are an exception. They require an acid soil—ideally pH 4.8 to 5.2. Soil test results help to guide applications of soil amendments such as compost, lime, gypsum, or other rock powders, to provide good soil conditions that meet the nutritional needs of the orchard.

In general, fruit crops do not require highly fertile soils for good production, though this varies with the species. Highly fertile soils, rich in nitrogen, can promote too much vegetative growth at the expense of fruiting in trees such as apples. A nutritionally balanced soil, proper soil pH, and plentiful organic matter are the fundamentals of an organic fertility management plan for fruits. Pre-plant soil improvement for organic fruit plantings usually involves some combination of cover cropping and applications of compost, natural minerals, or other organic fertilizers. More on this topic can be found in ATTRA's *Soils and Sites for Organic Orchards and Vineyards.*

Management Prior to Orchard Establishment

It's easier to manage weeds before an orchard is established. Cover crops (see ATTRA's *Overview of Cover Crops and Green Manures*) produce a thick stand that will shade or choke out weeds. Combined with a well-planned sequence of tillage, cover cropping is an effective pre-plant weed suppression strategy that also contributes to soil fertility and stable humus. The basic strategy begins with plowing under or disking the existing vegetation, ripping or deep chiseling to loosen compaction, planting a cover crop to suppress weed growth, mowing down and tilling under the cover crop(s), and, finally, planting the fruit crop. Several cover crop and tillage sequences may be necessary before planting.

Specific cover crops and management strategies vary with location and purpose. The cover crops you choose for site preparation (before planting the orchard) may be entirely different from those you want once the orchard is established.

Soil Solarization

Soil solarization is the practice of placing transparent plastic films on moist soil to capture solar energy. Solarization takes four to eight weeks to heat the soil to a temperature and depth that will kill harmful fungi, bacteria, nematodes, weeds, and certain insects in the soil. Solarization

Important considerations in site preparation include alleviating soil compaction, enhancing fertility, adjusting soil pH, and managing weeds, pests, and diseases.

can be a useful soil disinfestation method in regions with full sun and high temperatures, but it is not effective where lower temperatures, clouds, or fog limit soil heating. Other disadvantages of solarization as a weed-control method include its expense and disposing of the plastics. Solarization is most commonly used in smaller areas, such as greenhouses and nursery beds, though it has been used experimentally to treat orchard soils, either prior to planting or during establishment. Experiments are underway to evaluate using biodegradable spray mulches for solarization. Researchers emphasize that solarization should be seen as just one component of an integrated pest management system, rather than as a "stand alone" technology. For more information, see the ATTRA publication *Soil Solarization and Biosolarization*.

Managing an Established Organic Fruit Orchard

Orchard Floor Management/ Cover Crops

The orchard floor—the tree rows and alleyways—can be managed in a variety of ways, using tillage or mowing with cover crops, grazing, or mulching (described in detail in the Organic Weed Management section). Orchard floor management can control erosion, improve the soil, and provide beneficial insect habitat.

Cover crops in a walnut orchard. Photo: Rex Dufour, NCAT

A system that maintains full ground cover provides the best protection against erosion. Some fruit growers practice "clean cultivation," eliminating vegetation throughout the orchard, but this system has many disadvantages, even if accomplished with allowed tillage practices instead of organically prohibited herbicides. A bare orchard floor is prone to erosion, gradual depletion of organic matter, increased soil compaction, and reduced water infiltration. It's also difficult to move equipment through the orchard in wet weather

Several considerations weigh into the choice of an appropriate orchard ground cover:

- A ground cover that is actively growing in the summer uses water from the soil. This is a severe disadvantage in irrigated orchards where water is limited and expensive.
- Where they are adapted, orchard grass, fescue, and other cool-season grasses are practical because they go dormant during the heat of the summer, minimizing competition with the fruit crop for water. With proper fertility management, these grasses can also provide plentiful mulch. Likewise, grasses are a good choice in apple orchards, for example, where the excess nitrogen provided by legumes can actually reduce fruit yields.
- Many warm-season legumes are deep-rooted and compete with the trees for water. Normally, they should not be allowed to grow under the tree canopy. However, leguminous ground covers can provide significant nitrogen to fruit trees or vines. Grass and legume ground covers alike promote water infiltration and hold the soil in place during the rainy season. Ground covers help maintain and increase soil organic matter, which increases the soil's ability to retain moisture. Cool season legumes, such as fava or bell beans, vetches, and clovers, can also achieve these goals.
- Planting subterranean clover into established orchards can provide mulch, fertilizer, between-row ground cover, and beneficial insect habitat. This clover reseeds itself in early summer and dies back during the hottest part of the growing season, leaving a relatively thick, weed-suppressive mulch. This system is used in hazelnuts in Oregon, peach orchards in Arkansas, and for a variety

of orchard crops in California (UC SAREP Cover Crops Database, 2022), but not where winter temperatures regularly drop below 0° F. Subterranean clover can provide habitat for such beneficial insects as ladybeetles, syrphid flies, big-eyed bugs, soft-bodied flower beetles, and other predators.

Crop Rotation

In an organic orchard, crop rotation does not mean changing the economic crop itself, but diversifying the vegetation that grows around the fruit crop. California organic almond farmer Glenn Anderson describes how important maximum plant diversity is within the orchard and in the surrounding vegetation. He takes advantage of every practical opportunity to diversify vegetation: the orchard floor grows cover crops; the landscaping around the family home situated in the midst of the orchard provides shelter and food for a variety of beneficial species; the roadway, farm perimeter, and even the paths of the irrigation lines provide habitat for these beneficials. Research studies confirm the positive effects of organic practices on beneficial insects. Several articles reported on comparisons of yields, pest and beneficial insect populations, and water and air quality factors on Anderson's farm with those of his brother's adjacent, conventional almond farm (Bentley et al., 2001) and found favorable results with organic practices. Mr. Anderson gives credit for the health of his orchard to the host of creatures that contribute to ecological balance on the farm. He believes that all the trees, shrubs, and plants he encourages help to sustain beneficial insects, spiders, bats, and birds within and around the orchard.

Cover Crops

There are several steps and considerations for selecting and managing a ground cover:

- State your objectives in order of priority. For example: suppress weeds, break up soil compaction, add organic matter to the soil (increase tilth, water infiltration rates, and water-holding capacity), enhance soil fertility (fix nitrogen), attract and sustain beneficial insects, serve as a trap crop for pests.
- Take into account the climate, rainfall pattern, soil type, and potential for soil erosion.
- Describe desired growth patterns and characteristics: Does this cover crop have a tap root? Will it regrow if mowed? Does it fix nitrogen? How much biomass does it produce? Is it fibrous? How long will it take to break down? Will I need to mow or chop it to speed its decomposition? When should I incorporate it? Will it reseed itself? What is its potential to become weedy if it goes to seed? Does it attract insects? What kinds? Will it serve as beneficial insect habitat? Is it a host for pests? Can it be used as a trap crop?
- Consider planting techniques and timing: When and how should I plant a cover crop? How can I manage its growth for production of organic matter and nitrogen fixation? Are there seasonal weather constraints to getting equipment into the field? What methods provide the best germination rate for the effort—broadcast, drilled, frost-seeded (the technique of broadcasting seed so that it is incorporated by the motion of the soil freezing and thawing)? What equipment do I have available—disc, broadcast seeder, seed drill, flail mower, chisel plow, spading machine? What is the seed cost? Do I need to inoculate seed with Rhizobium bacteria to increase nitrogen-fixing nodulation?
- Is the best cover crop for my situation a single crop, a mixed seeding, or a series of different cover crops? The SARE publication *Managing Cover Crops Profitably* includes a guide for selecting the right cover crop for your purpose (SARE Outreach, 2007).

Pest Management

Organic pest management relies on preventative, cultural, biological, and physical practices. Organisms—insects, mites, microorganisms, or weeds—become pests when their populations grow large enough to prevent growers from reaching production goals. Integrated Pest Management (IPM) recognizes that the mere presence of a potentially damaging species does not automatically mean that control actions are necessary. Knowledge of pest life cycles and monitoring techniques developed in IPM programs are as useful for organic growers as they are for conventional growers.

Common arthropod pests of fruits include insects (aphids, caterpillars, leafrollers, twig borers, flies, psylla, scale insects, leafhoppers, mealybugs, earwigs, thrips, and beetles) and mites. Identification and preventative management

Organic pest management relies on preventative, cultural, biological, and physical practices. Organisms—insects, mites, microorganisms, or weeds—become pests when their populations grow large enough to prevent growers from reaching production goals.

Plum curculio. Photo: Margo Hale, NCAT

are essential to organic production systems. Identification charts are available from many university Extension websites and publications.

Managing vegetation adjacent to economic crops (fencelines, roadsides, etc.) as habitat for beneficial insects has a positive impact on pest management. These areas often include native plants and shrubs that flower at different times of the year, providing sources of pollen and nectar for beneficial arthropods.

Although there are many components to insect and mite pest management, in recent years there has been a good deal of research on vegetation management to enhance natural biological control. Cover crop and vegetation management may include the following approaches:

- resident vegetation that harbors beneficial arthropods (insects, mites, spiders)
- strip management of cover crops to ensure the continuous presence of habitat for both beneficials and pests
- insectary mixes of plants attractive to beneficial arthropods
- use of mulch from mowing to harbor generalist predators.

There is also increasing evidence that managing vegetation adjacent to economic crops (fencelines, roadsides, etc.) as habitat for beneficial insects has a positive impact on pest management. These areas often include native plants and shrubs that flower at different times of the year, providing sources of pollen and nectar for beneficial arthropods. See the ATTRA publications *Farmscaping to Enhance Biological Control* and *Companion Planting & Botanical Pesticides: Concepts & Resources.*

However, as a rule, **beneficial arthropods cannot provide complete control for pests that attack the fruit, at least not for commercial growers who have a low damage threshold for fresh fruit.** Usually, additional control measures are necessary. On the other hand, biological control for foliar pests (also called "indirect pests") is often practical.

The long-term nature of growing fruit using cover crops and other resident vegetation management can sustain populations of predators, parasites, and other beneficial organisms. There are many possible trade-offs, emphasizing the need for careful planning and the importance of research and monitoring.

For instance, though legumes can contribute nitrogen to the orchard system, some legumes are known to attract hemipterous pests like tarnished plant bugs and stink bugs. Where these pests are a problem, legumes may be less desirable as orchard cover crops, unless they can be managed as trap crops for lygus bugs. Alternatives such as mustards, buckwheat, dwarf sorghum, and various members of the Umbelliferae (carrot, cilantro, dill, fennel, anise, etc.) and Compositae (sunflower and other composites) families can support substantial numbers of beneficial insects without attracting as many pests. However, note that mustards flower and seed early, providing early-season food for hemipterans, including stink bugs.

Many organic walnut growers plant cover crops that are mixtures of legumes—such as bell beans, vetch, or alfalfa—to produce nitrogen and create a beneficial insect habitat, in combination with cereals that produce organic matter and provide support for the legumes. Growers alternate rows when they mow or disc, intentionally leaving strips of cover crops in the orchard to provide areas with flowering plants that sustain populations of beneficial insects.

In any orchard setting, it is important to watch for gophers and other rodents. Aside from their many benefits, cover crops can also provide food and cover for such potential pests.

Disease Management

Disease can be a significant limiting factor in organic fruit production. Diseases may be caused by fungi, bacteria, viruses, nematodes, mycoplasmas, or protozoans. Disorders caused by the weather or by nutrient imbalances (deficiency or toxicity) can create symptoms that look like diseases. Proper identification and preventative management are imperative. For example, boron toxicity or blossom-end rots cannot be cured with fungicides. Cooperative Extension and university websites can help with identification. The book *Organic Tree Fruit Management* includes detailed descriptions of diseases of fruit crops, including hosts, status (potential impact), symptoms, life

cycle, monitoring/thresholds for treatment, and organic management strategies (Edwards, 1998). Thresholds for action may be distinct in an organic pest management system (in which the impact of a disease organism is considered not only on this year's crop but also in terms of the future implications for control, potential buildup, and impact on the health of the trees), compared to conventional IPM programs (in which the availability and allowability of pesticides is assumed).

As described in the NOP standard, a combination of cultural controls forms the foundation for a good disease-management strategy. As discussed earlier in this publication, selecting resistant varieties or rootstock is of utmost importance, as is selecting the right growing location. In an established orchard, one can practice good sanitation by cleaning up debris, pruning, and removing diseased plants and disease vectors. Some plants can serve as alternate hosts for diseases. Eastern red cedars, for example, are alternate hosts for cedar-apple rust. Wild blackberries can harbor blackberry rust, and wild plums can foster peach brown rot. A good defense against plant disease is to maintain the crop plants in excellent health and vigor, with sufficient—but not excessive—soil nutrients and moisture.

Many diseases of fruit crops only affect a particular species and variety of fruit. There are, however, some diseases that are common to almost all temperate-zone perennial fruit crops. For instance, because of the relatively soft nature and high sugar content of most mature or nearly mature fruits, fruit rots are common afflictions. Sunlight and circulating air help to dry leaf and fruit surfaces, thereby limiting fungal and bacterial infections. The organic grower can help minimize fruit rots by allowing good air circulation and sunlight penetration into the interior plant canopy. In tree crops, this would mean proper pruning and training. In brambles and strawberries, reducing plant density helps. In grapes, adequate pruning and removing leaves that shade fruit clusters is beneficial. All fruit crops need a site that allows good air circulation. For some fruits, well-timed applications of allowed fungicides can be effective in an integrated disease-control program for mildew and fruit rots.

Brown rot on peach. Photo: Guy Ames, NCAT

Another problem common to many fruit crops is root rot and intolerance to poorly drained soils. Blackberries, most pear rootstocks, and some apple rootstocks are relatively tolerant of heavy or poorly drained soils, but even these crops will succumb to persistently water-logged conditions. Blueberries, raspberries, and *Prunus* species (peaches, plums, cherries, etc.) are very intolerant of poorly drained soils and are generally susceptible to root-rotting organisms common in such soils. Even in well-drained soils, blueberries and raspberries are often planted in hills or raised beds. Again, site selection is very important for maintaining plant health.

It is possible to make soils more disease-suppressive through the addition of significant amounts of organic matter. This has been most vividly demonstrated in Australia, where liming and cover crops—combined with applications of chicken manure, cereal straw, weed residues, and other materials—are used in avocado groves to control *Phytopthora* root rot. This strategy, known as the "Ashburner system," is now common practice in many areas where avocados are grown (Cook, 1982). In contrast, mulching apple trees in humid areas, such as New York, may increase *Phytopthora* root rot, especially on susceptible rootstocks like MM.106.

Fruit production resources compiled by Cooperative Extension can help in identifying fruit diseases and their life cycles. Some of the publications in the Further Resources section of this publication provide an excellent summary of fruit diseases.

Plant Health and Vigor

Maintaining plants in good health and vigor is important for insect pest management. For fruit plants, this is more applicable to indirect pests (those that feed on foliage, stems, etc.) than to pests that feed on the fruit. For instance, an apparently healthy plum tree may set a good

Diseases may be caused by fungi, bacteria, viruses, nematodes, mycoplasmas, or protozoans. Disorders caused by the weather or by nutrient imbalances (deficiency or toxicity) can create symptoms that look like diseases. Proper identification and preventative management are imperative.

crop of fruit, yet lose it all to the plum curculio. That same tree might suffer significant defoliation by caterpillars early in the season; yet, if it is in good vigor, it can compensate and bounce back quickly—still producing a marketable crop that year. There are some cases where general plant health and freedom from stress do impart a form of "resistance"—not technically genetic resistance—to certain pests. Two examples are apple trees in good vigor that actually cast out invading flathead apple tree borers by smothering them with sap, and plants not suffering drought stress being much less attractive to grasshoppers. For more in-depth information on designing an integrated pest management program for your farming system, please refer to the ATTRA publication *Biointensive Integrated Pest Management.*

Before you apply any product, make sure it's allowed for use in organic agriculture. Read the label carefully. Are all the active ingredients allowed? What about the inert ingredients? If it contains any undisclosed inert ingredients, you must have documentation from the manufacturer to confirm that all inerts are allowed by the National Organic Program.

Applying Materials: Pesticides Allowed in Organic Production

Allowed materials include only natural (non-synthetic) materials that are not specifically prohibited and specifically allowed synthetic materials, as described in 7 CFR §205.600-602 of the NOP. Most, if not all, allowed synthetic materials have annotations that closely restrict how (in purpose, application method, and quantity) they can be used. Before you apply any product, make sure it's allowed for use in organic agriculture. Read the label carefully. Are all the active ingredients allowed? What about the inert ingredients? If it contains any undisclosed inert ingredients, you must have documentation from the manufacturer to confirm that all inerts are allowed by the National Organic Program (on EPA List 4). If in doubt, ask your certifier before you use it.

Several disease-control materials on the market are allowed for use in organic agriculture, including biofungicides, mineral-based essential-oil extracts, and botanical fungicides. Growers in some regions are also using compost teas and plant extracts. The OMRI list provides information about the allowability of brand-name products, but not their efficacy. You can ask your local Extension agent about any research or use in your region. Copper and sulfur compounds are fungicides that are allowed (with restrictions on their use) and have been used historically by organic growers, but they have several drawbacks. These materials can damage plants if applied incorrectly. Sulfur dust can cause acute eye and respiratory irritation in humans. It is also lethal to some beneficial insects, spiders, and mites, and can set the stage for further pest problems. Long-term frequent use of copper fungicides can also lead to toxic levels of copper in the soil.

Fertilization

Fruits, being largely water and sugars, remove relatively few nutrients from the soil compared to other crops. Therefore, most of a fruit crop's fertility needs can be met through cover crop management and organic mulches (in systems that use them) and by the application of lime and other slow-release rock powders at the pre-plant stage. Supplementary fertilization may still be required for optimal growth and production.

There are many commercial organic fertilizers available. As noted above, however, organic growers should be familiar with organic standards, and especially the National List of Allowed Materials in the NOP's 7 CFR §205.600-602.

The NOP Rule requires that applied raw manure be incorporated at least 90 to 120 days before harvest of crops for human consumption (90 days if the edible portion does not have contact with soil or soil particles; 120 if it does). Compliance is easy: move grazing animals to another pen or paddock at the appropriate time.

For more detailed information regarding sustainable soil fertility management, including the use of organic fertilizers and nutrient testing methods, request ATTRA's *Alternative Soil Amendments,* and *Foliar Fertilization.*

Organic Weed Management

Some weed control methods, such as smother crops, are discussed in the Site Preparation section, above. This type of cover cropping is an important tool for weed management that also contributes to good soil management, fertility, and pest management.

Mulches

Organic Mulch. Mulching is a powerful weed-management strategy that can also contribute to good soil management, if appropriate natural materials are used. After a planting is established, weeds can be suppressed by applying thick layers of mulch. This can also create habitats for beneficial arthropods, including generalist predators such as big-eyed bugs, soft-bodied flower beetles, and

General Fertilizer Guidelines

- Organic fertilizers—especially uncomposted animal manures—should be incorporated into the soil to avoid nitrogen volatilization and to comply with organic standards. Use shallow tillage to prevent damage to plant roots and to minimize the potential for soil erosion. Manures should be incorporated into the soil at least three or four months before harvest (depending on the crop type) to comply with National Organic Program standards (7 CFR §205.203 (c) (1)).

- Soluble organic fertilizers such as fish emulsion, kelp, and soybean derivatives are suitable for use in drip irrigation and can provide quick supplemental fertility. Compost teas are usually more problematic for drip systems, as emitters can become clogged with fungal contaminants. Be sure to check with your certifying agency regarding current interpretations of the organic standards for compost production and any restrictions on the preparation or use of compost teas.

- Most organic fertilization programs focus on supplementing nitrogen as the key element, because it is needed in the greatest amount for the crop. You can calculate rates of organic amendments based on standard recommended rates for the crop, but be aware that many fertilizer recommendations still assume the use of synthetic materials. Organic systems behave differently. They generally use slower-release fertilizers and rely on biological activity to break them down into forms that can be absorbed by the plants. For example, only a portion (perhaps half) of the nitrogen applied as stable compost may be available to plants in the first year. The rest is stored and released gradually. To compensate for this, the producer may apply twice as much nitrogen as is needed in the first year of organic management. In subsequent years, however, more of the nitrogen is released from the soil organic matter and becomes available. In a mature organic farming system, nutrients and organic matter are added to maintain, replenish, and build the bank of nutrients in the soil.

- When making fertilizer calculations based on nitrogen, growers need to credit the estimated contributions made by legume cover crops and/or mulches. A cover crop of subterranean clover, properly fertilized and inoculated, can fix 100 to 200 pounds of nitrogen per acre annually in a “living mulch” system. Other legume cover crops may produce as much or even more, depending on planting date, weather, and mowing.

- Consider the overall fertilizer analysis; basing application rates solely on nitrogen content can cause problems when the fertilizers are not balanced to meet the needs of the crop. For example, repeated use of poultry manure, which is very high in phosphate, can lead both to pollution problems and to zinc deficiency in the crop. These problems can be avoided by regularly monitoring and adjusting fertilizer selection and rates.

- The most reliable way to determine whether fertilization is adequate is to combine field observations with soil or tissue testing. Poor yields, unusual coloration of leaves, and poor plant growth are all clues to a possible nutritional imbalance or deficiency. On most fruit trees, slow elongation of branches often indicates a nitrogen deficiency. Yellowing between the veins of new blueberry leaves usually means the plant is suffering an iron deficiency. Corky bark on certain apple varieties can indicate an over-availability of manganese in the soil.

- Foliar analysis measures the nutrient content of the leaves and can identify a nutrient deficiency or excess well in advance of visible symptoms. It is more helpful than a soil test because the foliar analysis is a measure of what the plant is actually taking up, while a soil analysis only measures what is in the soil—which may or may not be available to the plant. Annual foliar analysis generally provides the best guide for adjusting supplementary nitrogen fertilization.

Organic apple growers on California’s Central Coast say that most years they plant only rye or other grass cover crops, because leguminous cover crops would contribute too much nitrogen, inducing excess growth, creating more pruning work, and decreasing fruit production. Growers monitor their nitrogen levels through leaf-tissue and soil analysis, and manage their soil covers accordingly.

spiders. Organic mulches are usually applied in a circle around tree trunks or vines, and down the whole row in blueberries.

Commonly, tree fruit growers keep mulches away from the tree trunks, particularly in winter, to prevent voles or mice from gnawing on the bark and damaging young trees. Keeping mulches eight to 12 inches away from the trunk also reduces the likelihood of crown rot and other diseases in susceptible species—most notably, apples on certain rootstocks.

Mulch materials may include straw, spoiled hay, leaves, yard trimmings, woodchips, and sawdust. Many of these materials are inexpensive. Still, it's wise to weigh the benefits and risks of each, including hauling costs and the risks of their containing impurities and prohibited materials.

Municipal greenwaste may be available, either raw or from municipal or commercial composting operations. Growers must monitor the incoming product and remove any trash to keep undesirable material out of their fields. Growers should ask compost producers about the sources of their materials and any pesticides that may persist in them. Of particular concern are clopyralid and picloram, herbicides that are extremely resistant to breakdown, even after composting.

Because organic mulches decompose over time, they require periodic re-applications in order to continue suppressing weeds. However, their decomposition provides other benefits. Mulching with organic matter enhances soil aggregation and water-holding capacity. Researchers from 1937 to the present have consistently found that mulching is the best orchard-floor management system for retaining moisture (Skroch and Shribbs, 1986). In Michigan research, mulching was as effective as irrigation in encouraging tree growth (Kesner,1989). Mulch can also benefit the crop by moderating soil temperatures, thus reducing plant stress.

Applying wood chip mulch to serviceberry bush. Photo Guy Ames, NCAT

Organic mulches provide slow-release nutrients for the long-term health and fertility of the soil. Research indicates that potassium, phosphorus, and nitrogen (primarily from the slow breakdown of the mulch) are more available in mulched systems than in non-mulched systems. Some growers express concern that sawdust may acidify their soil or bind nitrogen in the soil. However, these effects are minimal if the sawdust is left on the surface and not tilled into the soil.

Raising organic matter on the farm is one way to ensure sufficient, clean mulching material. Farm-raised hay grown outside the orchard can provide weed-free mulch. Cover crops may be grown between tree rows, mowed, and gathered around the trees. Some small-scale growers use the biomass from orchard alleyways, cutting cover crops with a sickle-bar mower and hand-raking the material under the trees. Larger-scale operations often use forage wagons, straw-bale spreaders, or specialized equipment to mechanize mulching jobs. Millcreek Manufacturing Co. (see Further Resources section) has developed a row mulcher especially suitable to blueberry, bramble, and grape culture but also useful in tree-fruit orchards. The Millcreek machines are designed to handle bulk organic materials such as sawdust, wood chips, bark, peat, and compost.

Geotextiles. Geotextile mulches are paper or woven plastic fabrics that suppress weed growth. While they allow some air and water penetration, they may reduce water infiltration, whereas organic mulches increase infiltration. Geotextile mulches do not provide the advantages of adding matter and nutrients to the soil, and, if synthetic, they must eventually be removed. Geotextiles have a high initial cost, though this may be partially recouped in lower weed control costs over the materials' expected field-life—five to 10 years for polyester fabric; two to three years for paper weed barriers. Still, some growers find them useful for weed suppression in orchards, tree plantations, and cane fruit culture. The ATTRA publication *Soils and Sites for Organic Fruit Production* provides more detail on the use of geotextiles and outlines additional methods of

weed control, including mechanical cultivation, mulches, wood chips, and living mulches.

Sheet Mulch. You can also create weed barriers by sheet mulching: laying down layers of cardboard or newspaper and covering them with organic material. Sheet mulching increases the efficacy of organic mulch as a barrier against emerging weeds. Organic growers should avoid cardboard that is waxed or impregnated with fungicide, as well as color print and glossy paper, in order to be compliant with the National Organic Program standards (7 CFR §205.601(b)(2)(i) and 205.601 (c)).

Cultivation

Cultivation—using mechanical tillage and weed-harrowing implements—is the most widely used weed-management practice in fruit production. In systems that maintain permanent vegetation between rows, cultivation may be limited to the tree row under the dripline in an orchard or may extended one to three feet from the edge of the hedgerow in bramble plantings. The reverse is true where mulches are used in the tree row and cultivation is used to control weeds and incorporate cover crops in the alleyways. In any case, cultivation must be kept shallow to minimize damage to crop roots and to avoid bringing weed seeds to the surface.

Hand cultivation—enhanced with the use of a wheel hoe—can be effective in small-scale plantings. In large-scale plantings of trees or vines, where in-row tillage is desired, "mechanical hoes" such as Green Hoe are very useful. These tractor-mounted, PTO-driven cultivators can till right up to the tree or vine without damaging the plant. Attachment options include powered rotary tillage tools and scraper blades that can move soil either away from or toward the base of the crop plants. Scraper-blade attachments, commonly known as "grape hoes," have been used in vineyards for decades.

Herbicides Allowed for Use in Organic Production

A few herbicides currently emerging on the market are allowable for organic production, with restrictions on the location of their use. There is ongoing research on using materials such as vinegar, corn gluten, and citric acid as herbicides, although they are not yet widely used by certified organic growers. Such materials may have applications in organic systems, such as for spot treatment of noxious weeds.

Weeder Geese, Chickens, and Ducks

For many years, farmers have used geese to control weeds in perennial and annual crops, including strawberries, blueberries, bramble fruits, and tree orchards. In Oklahoma, researchers at the Kerr Center for Sustainable Agriculture used weeder geese in commercial-scale blueberry and strawberry production, with portable electric fencing to keep the birds in a specific zone in the plant row. Investigators at Michigan State University studied the impacts of populations of domestic geese and chickens in a nonchemical orchard system. They found that the geese fed heavily on weeds—especially grasses—and also on windfall fruit. In general, geese are more effective against emerging or small grass weeds, and they have a particular preference for Bermuda grass and Johnson grass—weeds that can be especially troublesome in orchards. ATTRA has additional information on weeder geese available on request.

Those who have raised chickens know how enthusiastically they devour fresh vegetation. If the area they inhabit is small, they will strip it to the dirt. Properly managed, however, their foraging characteristics can be used to the grower's advantage.

Fred Reid is an innovative producer of raspberries and vegetables in Canada who has successfully employed his flocks of chickens in weed management. He uses a system of fencing to keep chickens in certain areas to accomplish a thorough job of weeding and insect control. He notes that if the vegetation has grown too high and the plants become too fibrous, the chickens will not eat them. However, if tall vegetation is mowed in advance, the chickens will process it readily. He excludes the chickens from raspberry plots when the new, tender leaves are emerging and, of course, near harvest time (Reid, 2002).

Flame Weeding

Flame cultivation uses directed heat to kill weeds. It works not by burning the weeds but by searing them and causing the plant cells to rupture. Farmers began using tractor-mounted flamers in orchard and row crops in the 1940s. Technology and technique have both been refined considerably in recent years. Several tools now commercially available, including flame, infrared, and steam weeders, make heat a viable option for some weed management applications.

Cultivation—using mechanical tillage and weed-harrowing implements—is the most widely used weed-management practice in fruit production.

Management of Vertebrate Pests: Mammals and Birds

Several bird species, deer, rabbits, ground squirrels, gophers, mice, voles, raccoons, and other animals can be serious pests of fruit plantings. Organic certification calls for an integrated approach to vertebrate management, including exclusion, trapping, repellents, scare devices, and protection or development of predator habitat.

For example, gophers and ground squirrels can be managed on organic farms through integrated strategies. Thomas Wittman of Gophers Limited emphasizes that growers should not expect to eliminate these pests but will do well to keep populations in check. He stresses the importance of keen observation and has tips for effective trapping routines using commercially available traps. Persistent year-round trapping is the primary strategy for most farmers, complemented by enhancing the habitat of key predators such as owls and hawks with nestboxes, perches, and appropriate vegetation. For more information, consult the ATTRA publications *Gophers: Vertebrate IPM Tip Sheet* and *Rats, Mice, and Voles: Vertebrate IPM Tip Sheet.*

Explosive propane devices are effective against gophers and ground squirrels. Propane gas ignited in rodent burrows creates an explosion that kills the animals and disrupts their tunnels. Several organic orchardists say that this works, but most promptly abandoned its use because neighbors complained about the noise of the explosion, similar to the sound of a gunshot. Only two materials (sulfur dioxide for underground smoke bombs and Vitamin D3, or Cholecalciferol) are on the National List as rodenticides. These may be used only if they are documented in the Organic System Plan, used with care to avoid harming non-target animals, and utilized only when other management practices are ineffective.

Crow damage to Asian pears. Photo: Guy Ames, NCAT

Birds can be especially troublesome in cherry, berry, and grape plantings. Exclusion with bird netting is probably the surest control, but the initial cost can be high for both the material and its placement. Noise devices, "scare-eye" balloons, Mylar tape, artificial hawk kites, and many other home remedies have been tried, with varied success. Successful scare tactics depend on the bird species, bird population pressure, and the grower's management of the devices. It is important to remember that birds and other vertebrate pests are quick to learn, and they often overcome their initial aversion to scare devices or repellents. The grower will achieve the most effective control by moving devices frequently, and by changing or mixing the devices. For example, organic growers describe how they effectively scare certain bird species away from newly emerging crops by placing red- and silver-colored Mylar tape in the field for just a few weeks, then removing it so that the birds do not get used to seeing it. Fruit growers use sonic and visual scare devices only at critical times in the growing season, such as fruit ripening, and remove them promptly as soon as that period is over. The ATTRA publication *Beneficial and Pest Birds: Vertebrate IPM Tip Sheet* offers additional information.

Deer can be devastating to fruit plants—especially young orchards. Methods for preventing or controlling deer damage to crops range from exclusion and cultural methods to scare devices, repellents, and culling or harvest. Scent and taste repellents may be effective under light deer pressure, especially if the grower switches periodically from one repellent or deterrent to another. Research at the University of Wisconsin indicates that none of these repellents is very useful under heavy deer pressure. Exclusion fencing may be the only way to manage heavy deer populations. In most states, Cooperative Extension provides plans for deer fencing. Electric fencing appears most effective. Research indicates that even a single strand of electrified wire can work. Where deer problems are severe, however, a seven-strand, sloped, electrified fence may be necessary.

Tree guards made of plastic, hardware cloth, or similar materials can keep rabbits from gnawing

on fruit tree trunks. However, northern growers should remember that snow can effectively raise the gnawing height of rabbits.

Mice and voles may be attracted to mulch around fruit plants. Such rodents take up residence in mulch during the winter, feeding and gnawing on roots, stems, and trunks. To reduce the chance of vole damage, mulch should be raked away from the plants in the fall (usually 18 to 24 inches is adequate). Mulch removal may not be practical, however, for blueberry plantings. Keeping the planting site mowed also helps reduce rodents by exposing them to natural predators such as hawks and owls. For pests such as raccoons, opossums, skunks, etc., tight web-type fencing or non-lethal traps are the best control options

Postharvest Handling

Many fruits require some type of postharvest handling. Whether done on-farm or off, these processes must be documented in the Organic System Plan. Any off-farm postharvest handling must be done by certified organic facilities, and appropriate measures must be taken to prevent commingling or contamination of organic products with non-organic products during washing, sizing, packing, and storage. A complete audit trail must track produce from its field of origin to the point of final sale. Growers should read the National Organic Program Final Rule, review the National List and OMRI lists, and consult with their certifiers about any materials to be used postharvest, such as cleansers, shellacs, or waxes.

Conclusion

Organic fruit production is a practical option for some growers, but the viability of the enterprise will likely hinge on site, scale, type of fruit, markets, and managerial skills. In general, crops grown in the drier climates of the West have fewer disease and pest problems. This region may, therefore, be better suited to organic fruit production, at least as long as irrigation is available. Strawberries, bush fruits, and brambles are probably easier to grow organically in most sections of the country than grapes and tree fruits. Management requirements for organic production are likely to be higher in any region, and the producer must be closely attuned to local site conditions.

References

Bentley, Walt, Lonnie Hendricks, Roger Duncan, Cressida Silvers, Lee Martin, Marcia Gibbs, and Max Stevenson. 2001. BIOS and conventional almond orchard management compared. California Agriculture. Vol. 55, No. 5. p. 12-19. calag.ucanr.edu/archive/?article=ca.v055n05p12

Cook, R.J. 1982. Use of pathogen-suppressive soils for disease control. p. 51-88. In: R.W. Schneider (ed.). Suppressive Soils and Plant Disease. APS Press, St. Paul, MN. p. 56-57.

Edwards, Linda. 1998. Organic Tree Fruit Management. Certified Organic Associations of British Columbia.

Kesner, Charles. 1989. Mulching fruit trees in northwestern Michigan. Great Lakes Fruit Growers News. May. p. 34.

Reid, Fred. 2002. Integrating Layer Chickens into a Certified Organic Raspberry and Vegetable Farm. 14th IFOAM Organic World Congress Proceedings. Cultivating Communities. p. 80.

SARE Outreach, 2007. Managing Cover Crops Profitably. Sustainable Agriculture Research and Education. sare.org/resources/managing-cover-crops-profitably-3rd-edition

Skroch, Walter A., and J.M. Shribbs. 1986. Orchard floor management: An overview. HortScience. Vol. 21, No. 3. p. 390-394.

UC SAREP Cover Crops Database. 2022. University of California, Davis, Sustainable Agriculture Research & Education Program. sarep.ucdavis.edu/covercrop

Further Resources

Sources of Supplies

This list is not comprehensive and does not imply endorsement of these companies by NCAT's ATTRA Sustainable Agriculture program or by USDA.

Flame Engineering, Inc.
flameengineering.com
P.O. Box 577, LaCrosse, KS 67548-0577
913-222-2873
800-255-2469 (toll-free)

Green Hoe
greenhoecompany.com
95 Industrial E.
Clifton, NJ 07012
833-473-3608

Harmony Farm Supply
harmonyfarm.com
P.O. Box 460
Graton, CA 95444
707-823-9125

Millcreek Manufacturing Co.
millcreekmfg.com
525 Reservoir Road
Honey Brook, PA 19344
800-311-1323

Thermal Weed Control Systems, Inc.
N1940 Hwy. 95
Neillsville, WI 54456
715-743-4163

Periodicals

American Fruit Grower

Good Fruit Grower

Fruit Growers News
(formerly Great Lakes Fruit Growers News)

Pomona North American Fruit Explorers

Books and Publications

Organic Tree Fruit Management. 1998. By Linda Edwards. Certified Organic Associations of British Columbia, Keremeos, B.C. Canada.
This book is available through Organic BC organicbc.org/product/organic-tree-fruit-management

The Holistic Orchard. 2011. By Michael Phillips. Chelsea Green Publishing, White River Junction, VT.
Phillips covers organic production of tree fruits and berries. Especially helpful for growers in the northeastern United States.

Uncommon Fruits Worthy of Attention. 1991. By Lee Reich Addison-Wesley, Reading, MA. 273 p.
Though not expressly for commercial growers, it provides otherwise hard-to-find information on minor fruit crops like pawpaws, jujubes, mulberries, etc.

Online Resources

U.C. Fruit and Nut Research and Information Center
This site has links to specific crops, lists of farm advisors, current research, and many other useful resources.

UC Davis Postharvest Technology Research and Information Center
This site provides practical information on postharvest handling of many products.

University of Missouri Extension Publications
This site includes information for home orchards.

California Rare Fruit Growers
This organization covers a fascinating plethora of tropical fruits but does not have a commercial emphasis.

Cornell Cooperative Extension Organic Fruit Production Guides
A series on organic production of various fruits.

Western Maryland Research & Education Center
There are many other state programs that have information on fruit growing, which may or may not have significant resources for organic orchard production.

The Mid-Atlantic Regional Fruit Loop
A cooperative effort bringing together information on deciduous fruit tree production in the Mid-Atlantic region. Cooperating state universities include Virginia Tech, West Virginia University, the University of Maryland, Penn State University, and Rutgers University.

North American Fruit Explorers
Members of this network are professional and amateur fruit growers who share information here and in their quarterly journal, Pomona (see Periodicals *section).*

UC Davis Pomology Dept
Links to all sorts of fruit information from University of California.

University of Massachusetts Tree Fruit Advisor
Fact Sheet series addresses specific issues and crops. Information focuses on apples but includes peaches, pears, plums, and cherries.

USDA articles and updates on organic farming
This site features tidbits of information on specific issues: Economic Research Service briefing room, organic farming and marketing, recommended readings.

Tree Fruits: Organic Production Overview
By Guy K. Ames, George Kuepper, and Ann Baier
NCAT Agriculture Specialists
Updated February 2023 by Guy K. Ames

Tracy Mumma, Editor • Amy Smith, Production
This publication is available on the Web at:
ATTRA.NCAT.ORG
IP028
Slot 33
Version 021623