

4.1 SITE SELECTION AND PREPARATION

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“Because I already own the land” may be the poorest reason for planting an orchard on a given piece of property. Site selection is one of the most important decisions a grower will make over the life of an orchard. Virtually every aspect of production and marketing is, to a degree, affected by site. It affects cropping consistency, fruit quality, pest pressures, and marketing success.

Spring frosts and freezes are the major factors limiting cropping consistency. Sites that are elevated relative to the immediate surroundings offer some protection from radiation frosts as well as a certain measure of disease protection. If planting on a slope, how close to the base of the slope to plant depends on the width of the valley at the base of the slope, the drainage area (from how large an area will cold air be draining into the valley), and whether there are any obstructions to air flow out of the valley.

Direction of slope can affect orchard performance. Trees on a south-to-west-facing slope may be more prone to cold injury (southwest trunk damage) than those on other slopes. Trees on a north-facing slope will bloom a bit later than those on other slopes, especially a south-to-southwest slope, and are, therefore, less prone to spring frost damage. Slopes with an eastern exposure receive morning sun earlier than others. Fruits and foliage on this

slope may dry off earlier in the mornings, thus reducing pressure from certain diseases.

Peach trees grow best on deep, well-drained, medium-textured soils having moderate fertility. Heavy, shallow soils should be avoided, as root growth will be restricted and trees will be more seriously impacted by drought, excess water, and low temperatures. Soils should provide a minimum of 30 to 36 inches of rooting depth, with greater rooting depths being desirable.

Avoid soils having poor internal and surface water drainage characteristics. Peach trees will not tolerate waterlogged soils for extended periods of time during the growing season. Tile drainage and planting on raised beds may improve tree survival, growth, and fruiting on marginal sites. However, such practices are expensive. Frequently, such sites have other limitations, such as poor air drainage. Excessively droughty soils may not be desirable either, because the higher frequency of irrigation required will add to the cost of maintaining such orchards.

Highly fertile soils do not necessarily make good peach sites. Excessive tree growth can cause shading in the lower and interior portions of trees. Undue vigor will contribute to increased disease pressure, poor fruit quality, and a failure to develop flower

buds for the following year in the lower and interior portions of the tree. Fertilizer can be added to soils of low to moderate fertility in sufficient amounts and at the correct time to obtain the desired results.

Water availability and water quality should be assessed in searching for orchard sites. If overhead irrigation will be used for frost protection and drought relief, a fairly substantial water source will be needed. If a stream is to be used as the water source, flow rate and reliability must be assessed to be sure that adequate amounts of water are available during peak demand periods. If a pond is to be used, its size and recharge rate must be adequate to satisfy the demands. With trickle irrigation, water quality is important because lines and emitters can easily be plugged by contaminants. Adequate filtration must be used to assure a clean water supply.

Location of the water source in relation to the orchard is important because pumping water excessive distances is expensive. Also, having to travel very far to fill sprayers adds a lot of time and expense to orchard care.

Water quality can have a tremendous impact on food safety considerations. Livestock should not have access to ponds or streams that may serve as water sources for orchards, as fecal contamination is a serious food safety risk. Concerns over marginal water quality are magnified by overhead irrigation because leaves and fruits will be wetted. Water quality will be of increasing significance as the technology to further enhance food safety continues to grow.

Market considerations should play a large part in site selection. If fruit is to be transported to a central packing facility, distance and the quality of the roads need to be considered. Retail, on-farm markets need to be readily accessible to customers. Locations that are easy to find and are close to population centers along paved roads that are wide enough to allow safe passage are positive factors. This is not to say that consumers will not visit markets lacking these features. However, visits to a market are likely to be reduced if the market is not easy to get to, or if roads are dusty, muddy, and filled with potholes or ruts. Adequate room

to load trucks or park cars is essential in the orchard or at packing houses and markets.

Previous cropping history should be assessed when evaluating a site. If the field has been in row crops, were persistent herbicides used that may injure or kill new trees? It may be necessary to delay planting such sites until these herbicides have degraded to the point that tree health would not be adversely affected.

Sites that were in hardwood timber can present root rot problems for the peach trees, especially if oak trees were present. Oak root rot can be a problem for peach trees even after the oak trees have been gone for a number of years. Sites known to have peach tree short life are obviously less attractive as replant sites.

Site selection and site development go hand-in-hand. Some factors in site development, such as water availability, passive frost protection, and ensuring adequate water drainage, are best addressed through selection of good sites.

Site preparation should establish a favorable soil environment for the trees and address factors that may have a negative impact on fruiting and orchard management. Orchard site preparation should begin at least six to 12 months in advance of planting. Factors to be addressed well in advance of planting include soil testing for pH, nutrients, and nematodes. Soil drainage, noxious weed control, orchard floor cover crop establishment, and other considerations should also be attended to before trees are planted.

Collect pre-plant soil samples well in advance of planting to allow adequate time to apply needed soil amendments. Samples should be collected in the upper 8 inches (discard the upper inch) and the 8- to 16-inch depth. The deeper sample may well be the most important at this time. Needed modifications in pH or nutrient status can be made at this time; after planting, deep incorporation of soil amendments is no longer an option.

A single soil sample should not represent an area exceeding ten acres. Within this area, additional samples should be collected where there is a change in soil type or where differences in



growth of vegetation might indicate a difference in soil fertility.

Soil pH should be adjusted to 6.5 prior to planting. If the 8- to 16-inch depth sample indicates a need for lime or nutrients, they should be applied and incorporated into the subsoil. If soil tests call for the application of four tons or more of lime per acre, apply two tons per acre and incorporate it deeply. Apply the remainder to the soil surface and incorporate by disking.

The basic soil test consisting of pH, phosphorus, and potassium should be adequate unless experience in your area would suggest the need for testing for additional nutrients. Additional information on soil testing and supplies are available at your county extension office.

Soil testing for nematodes is warranted for most sites. This topic is addressed in detail elsewhere in this reference.

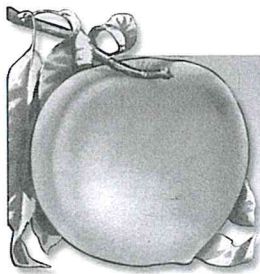
Noxious weeds should be controlled in advance of planting because the selection of effective herbicides is greater and the dangers accompanying misapplication are less at this time. Be sure to select a non-persistent herbicide that will not affect survival or growth of new peach trees.

Address any problems with poor internal or surface water drainage before planting. Tiling, terracing, and establishment of surface waterways should be addressed pre-plant.

Obstacles such as hedgerows or woodlands that might impede good air drainage out of the site should be removed.

If the field is smooth and already has a good sod cover, herbicides may be applied in the summer or fall before planting to a 4- to 6-foot wide strip where the rows will be located. If the field is rough or has no sod cover, it should be worked and seeded in late summer or fall preceding planting. Lime and nutrients should be applied based on soil test results prior to tillage. If a permanent cover is not established in fall, a cover crop should be planted to help control erosion.

If the orchard site is wooded, allow enough time before planting to remove the trees and stumps, adjust pH and nutrient levels, and establish a ground cover. Pine timberland can be a good orchard site if the soil and water drainage characteristics are favorable. Sites that had hardwoods on it may need to be avoided for many years because of root rots, particularly oak root rot, which can be lethal to peach trees.



4.2 DETERMINING POTENTIAL FOR REPLANT PROBLEMS

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Peach orchards are often planted with the optimistic expectation that they will bear fruit in three years, become profitable in five or six, and then remain vigorous and productive for another 10 or more years. These expectations may be reasonable for many new orchards sites, planted to virgin land, but out of necessity, many orchards are planted to old peach sites. On replanted sites, such longevity and productivity are seldom realized. Instead, replanted orchards frequently show signs of early tree decline and death by the fourth to sixth season and by year 10 to 12 they are plagued with low production and premature tree losses. This early, progressive decline is seldom due to any one factor but, instead, to a complex of many different factors acting in concert to produce what is loosely characterized as orchard replant disease syndrome (ORDS). As a general characterization, ORDS lacks the precision required for definitive diagnosis and treatment but, as a broad concept, it is useful in first understanding and then managing old orchard sites.

THE CONCEPT OF ORDS

ORDS is not an unusual phenomenon, but a common and natural ecological consequence of long-term monoculture that can and should be anticipated.

Land that was originally well-suited for peach tree production changes dramatically over the life of an orchard, becoming increasingly, even selectively, more hostile to peaches. Because a susceptible host is planted, populations of resident, soil-borne pathogens increase selectively over time. Among the most significant of these resident-site pathogens are various nematode species (dagger, lesion, ring,

and root-knot nematodes), several root and crown rotting fungi (*Armillaria*, *Clitocybe*, and *Phytophthora* spp.), and, in the mid-Atlantic production area, a serious virus (tomato ringspot virus, the cause of *Prunus* stem pitting).

Because peach trees are perennial, pathogen introduction and establishment are progressive in the orchard ecosystem. Here, we can include the nearly ubiquitous and opportunistic pathogens that cause *Cytospora* and bacterial canker diseases, both of which have been implicated in peach tree short life (PTSL) complex. PTSL is a better defined and more specific form of ORDS. In some regions, pathogens such as *Prunus* necrotic ringspot virus and the mycoplasmas that cause peach X-disease and peach yellows have not only invaded orchards, but may also be established in wild, alternative host species in areas surrounding the orchard site.

Not all of the factors associated with ORDS are pathogens. Because the orchard soil profile remains largely undisturbed and practically inaccessible at lower depths once the trees are planted, many other abiotic or non-pathogenic factors also change during the life of the orchard. Some of the most important factors include: depletion of vital mineral nutrients and organic matter or their stratification within the soil layers; increased soil acidity at lower depths; and changes in soil structure that directly or indirectly affect water drainage, soil aeration, and root development. To this list we must also consider occasional instances of severe cold injury, droughts, and misapplication of certain herbicides, all of which interact with other site factors and affect tree health and survival.

The net result of all these changes is the development of an entirely different ecosystem from the one in which the old orchard was first started. In general, most pathogenic factors are directly involved in the decline and subsequent death of trees, usually with the production of recognizable symptoms. By contrast, many abiotic factors develop slowly, and typically produce few distinct symptoms. Abiotic factors play a very important role in ORDS by weakening trees and predisposing them to pathogen invasion or to more severe winter injury which, in turn, allows a number of canker-causing pathogens to prosper. In addition, because of the additional stress such abiotic factors impose on tree growth and function, they often exacerbate already established pathogenic relationships such that the symptoms of decline appear and progress more rapidly. For example, trees infected with tomato ringspot virus usually show symptoms within four years after planting, but under drought stress can develop symptoms in just two years.

The fact that some mature trees on old sites do well in spite of many limiting factors can lead to a false sense of hope for successfully replanting a site. Mature trees that established early-on developed strong root systems that allow them to tolerate considerable stress. Unfortunately, young, bare-rooted trees thrust into such an inhospitable environment are under stress from the start. They never become well established, and quickly develop symptoms of ORDS.

From even this elementary overview of ORDS, it should be apparent that in order to return an old orchard site to its full productive potential, we must look for ways to effectively renovate by destroying much of the old ecosystem to begin anew. The breadth and complexity of ORDS very often ordains that specific decline factors, while similar on all sites, vary greatly in relative importance by both region and individual site. Thus, before a suitable treatment plan for replanting a site can be developed, the potential risks of many factors must be carefully considered. Doing this requires a measured, systematic process of getting the right information, making objective decisions, and then following with the most appropriate timing and sequence of treatments for reclamation.

GETTING THE RIGHT INFORMATION

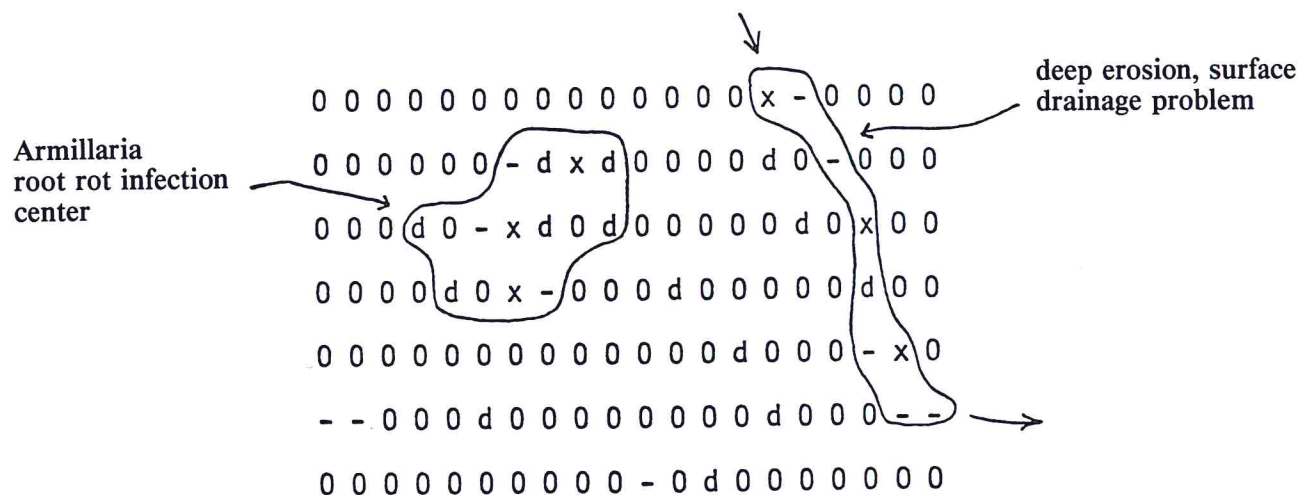
Orchard History. Planning the replant operation should begin when the first fruit tree is planted on a site, not when the last tree is pulled. Admittedly, planning a replant operation 15 to 20 years in advance seems excessive. However, the history of the old orchard site, how successful or unsuccessful it was, is the most important information for planning the new orchard. Destroying the old orchard before the evidence of past problems and mistakes can be accurately identified and assessed is, typically, the most common and costly error made in replant operations.

Developing a good historical record of an orchard site is not difficult. Begin with two questions. First, did the old orchard always do poorly? If so, and reasonable care was taken in orchard establishment, the site itself may be marginal and should be retired from orchard use. Second, did the old orchard decline slowly over many years after it reached maturity? Where this is the case, two more questions need to be posed. Is the decline in productivity reflected largely in fewer bushels per tree? Or is the decline more likely due to fewer trees surviving per acre? Declining productivity per tree suggests a need for special attention to addressing problems with soil pH, overall nutrient levels, plant parasitic nematode populations, and cultivar suitability. If tree death is the major problem, give special attention to assessing the role of nematode populations, soil-borne fungi, viruses, and other major pathogens.

Orchard Mapping. The easiest way to systematically document problems, so both incidence and severity can be assessed, is by preparing a good orchard map (Figure 4.2.1). Mapping should be done at least one year before the old orchard site is cleared, although maps prepared earlier and then periodically updated are more useful. As a rule, map orchards each six to eight years, and add an additional mapping if the old orchard was also a replant situation. Thus, for an 18-year-old orchard, three mappings should provide information not only on the pattern of tree decline and death but also on the rates and specific locations of tree loss.

Getting a working map down on paper where you can begin to use it for decision making is neither

FIGURE 4.2.1. Orchard block tree inventory map useful for planning the replant operation. Map should be developed well in advance of clearing the orchard in order to diagnose problems.



Key: 0 = healthy; d = early decline; x = dead or dying; - = tree missing

difficult nor particularly time consuming. A large pad or notebook of quadrille-ruled (1/4-inch squares) paper, a pencil, and a vehicle are all that is needed. Drive slowly through the orchard, marking the tree positions and their general condition for up to four rows on either side of the drive row. Identify each tree space with one of four marks noting apparently healthy trees (O), trees in early decline (D), dead or dying trees (X), and missing trees (-). Maps should include cardinal direction, the locations and nature of adjacent habitats, and major surface drainage channels and low spots subject to prolonged soil saturation.

Diagnosing Major Pathogen Problems. Using the orchard maps as a guide, any group of trees in decline or the margins of areas where trees are weak, dead, or missing should be examined for symptoms of soil-borne diseases. Few soil pathogens can be accurately identified on the basis of limb and foliage symptoms, but good diagnostic evidence can usually be found at or just below-ground between the graft union and the root crown. Several different pathogens or other problems may be involved, making broad assumptions on the basis of examining a few scattered trees very misleading. Special attention should be given to areas with poor surface water drainage. It is easy to assume that trees in these areas struggled or died because their root systems were water-logged for long periods. However, the stress imposed by frequently saturated soils also encourages the

establishment of the *Armillaria*, *Clitocybe*, and *Phytophthora* root rot fungi; this possibility should be considered carefully.

A common mistake in diagnosing the causes of tree decline or death is to prematurely attribute the damage to winter injury. Winter injury is certainly a key decline factor, but this diagnosis should be weighed carefully when an isolated tree or small group of trees that succumbed are surrounded by otherwise healthy trees exposed to the same winter conditions. Indeed, the symptoms of winter injury may be legitimate, but look further for evidence of some factor or factors that may have predisposed a given tree to that injury. It may only be damaged by borers, mice, or farm equipment, but it may also be one of several serious soil-borne diseases which might require special treatments before replanting.

Soil Sampling. No orchard site, new or replant, should ever be planted without first thoroughly sampling the soil for plant parasitic nematode populations and determination of soil pH and fertility levels. Soil samples will be the basis for decisions involving considerable expense for soil fumigation, for several tons of lime and fertilizer per acre, and, ultimately, the potential for success with the new orchard. It is important, therefore, that all sampling be done carefully and that the results are recorded on orchard maps for further reference. Areas where dagger nematode populations are high, for example, should be thoroughly

examined for evidence of stem pitting disease, which, if present, will influence other decisions governing weed control during the replant operation.

Soil samples for nematode analysis should be taken in a general sampling from across the area to be planted, as well as from specific problem areas identified by mapping. Use a soil-sampling tube and select an equal number of soil cores from the tree dripline areas and from a zone midway between the trunk and dripline. Sample to a depth of 16 to 18 inches, and no less than 12. For general samples, select trees at random across the whole site, taking at least two soil cores from beneath each of 20 trees. Collect the cores in a bucket, mix them thoroughly but gently, and then select about a pint of soil for submission for a nematode assay. One or two samples per five acres is generally sufficient. Additional samples are needed where there are major differences in terrain, soil drainage, and in areas with higher numbers of weak and/or dying trees.

For an accurate determination of nematode populations, nematodes must be alive and healthy enough to swim out of the soil, through a filter, and into a collection vial. For this reason, special care is needed in collecting and handling the soil before the assay is done. Do not add water to the sample and, most importantly, protect it from heat.

Soil samples for determining soil pH and fertility levels can be taken after the trees are removed, but before the first and each subsequent cover crop is planted. Separate samples should be taken from areas where bulldozers were used to reshape the land and large amounts of subsoil were exposed or mixed into the topsoil. (These areas may require special lime and fertilizer amendments.) All samples should be taken to a depth of 16 to 18 inches.

MAKING DECISIONS

Some decisions can be made after preparing site maps and determining if major soil-borne pathogens are present, evaluating soil pH and fertility factors, and accessing soil drainage. The first and most obvious decision is whether it is a good idea to replant the site. The presence of fruit trees on a site should not justify replanting and potentially

repeating a mistake. Be objective and realistic in judging the frequency and severity of air and water drainage problems with the previous orchard and whether major changes in and around the site can easily and economically be made using heavy equipment.

Do not count on luck or post-plant nematicides to assure good orchard productivity and longevity if soil-borne pathogens, including nematodes, are not addressed pre-plant. You may be able to avoid serious long-term problems by retiring the problem site. Where the cost of pre-plant soil fumigation of the whole site is prohibitive, consider using the orchard maps to identify and rank for priority treatment two or three sections within the larger orchard rather than replanting. The cost of fumigating and replanting can be spread over a two- to three-year period if you treat the least productive areas first.

If you decide to fumigate, remember there is but one pre-plant opportunity to select the right fumigant and apply it correctly. Errors here are costly and may go unrecognized until after planting, when they cannot be corrected. Considering the complex nature of most orchard replant problems, the use of broad-spectrum soil fumigants is, by far, a better all-around option than using materials that are primarily for nematodes only. In some cases, it is advisable to hire experienced custom applicators who have and can use specialized equipment to do the job efficiently.

SCHEDULING THE REPLANT OPERATION

Time. Next to destroying an old orchard before the potential for ORDS can be assessed, the second most common and costly error in replanting old sites is failing to allow sufficient time between old tree removal and the setting of new trees. Time alone, without a susceptible crop, will help reduce the populations of some pathogens. Many nematode species, however, will maintain substantial populations on popular cover crops such as corn, grasses, or weedy vegetation. If perennial broadleaf weed populations are not rigorously controlled during the reconditioning period, the chances for carrying over tomato ringspot virus (cause of *Prunus* stem pitting) are very high. If *Armillaria*

or *Clitocybe* root rot fungi are established on an old orchard site, they will persist on old root residues for many years. Obviously, it is neither practical nor economical to allow good orchard sites to remain out of production for an extended period while we wait for pathogen populations to diminish; we need to hurry the process along, but not too fast.

Crop Rotation. A practical approach to orchard site renewal is to plan on a minimum of two years rotation between tree removal and replanting. During this interim, several small grain, corn, or sudex crops can be grown and turned under to increase soil organic matter. Sometimes corn or small grain crops are chosen for this purpose as a way of gaining some income. In the mid-Atlantic area, the modest returns of small grain or corn, and their limited contributions to soil conditioning, compared to the conditioning needed for a new, productive orchard soil, favor use of sudex. It develops a very deep, penetrating root system that may help open up compacted soils more than any other cover crop. In addition, sudex grows rapidly and produces a lot of vegetative growth that can be mowed and turned under to incorporate large amounts of organic matter into the soil.

Soil Preparation. Several applications of lime and basic nutrients should also be made and incorporated over the two-year period when growing several cover crops. In each case, the amounts added should be based on new soil samples. If materials are incorporated in several different operations, a more uniform and stable fertility status, pH, and soil structure is developed than if amendments are applied all at once based upon a single sampling procedure. Make the largest addition of lime and basic fertilizer early, and then follow with minor adjustments and special tree and fruit nutrient needs (e.g., boron) closer to planting time.

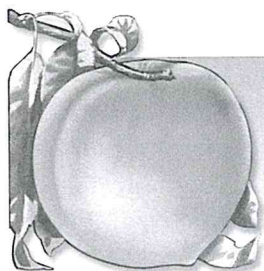
The repeated plowing and disking of old sites to incorporate lime, fertilizer, and cover crop residues has the added benefit of exposing many of the buried peach roots not removed during the initial clearing operation. All of these roots, of course, must be collected and either burned or removed from the site (the same is true where orchard areas are being expanded into former woodlots and wooded fence rows). Such roots

harbor a variety of soil-borne pathogens that otherwise will persist in the soil for many years, even where fumigation is used. Reworking the soil over the two-year period does a better job of shattering hardpans to correct problems associated with compaction and with poor internal and surface water drainage. Finally, incorporation of organic matter (such as sudex) provides the basis for good populations of beneficial microbes deep in the soil profile.

The ultimate goal of all this activity is to dramatically change the old orchard soil ecosystem (which otherwise will support the development of ORDS), and to establish a new orchard soil profile that will promote rapid, early root development. If, in the rush to get new trees planted, all of these operations are collapsed into a short period of weeks or months, this important advantage is lost and the results are almost always disappointing.

SUMMARY

Good disease management is based on two principles: reducing the amount of primary inoculum (pathogen populations) available to start disease and reducing the rates at which infections develop. Good management of the replant situation requires measures that address both of these principles. As a rule, the pathogenic components of ORDS govern if and how trees die, whereas the abiotic site factors often determine how rapidly ORDS develops. Time, thorough removal of old root residues, cover crops, and soil fumigation are the primary means for reducing soil-borne pathogen populations within a recommended two-year rotation between orchards. Establishing a uniform soil profile with respect to organic matter content, general fertility, pH, and soil structure promotes the early, rapid establishment of fruit tree root systems and greatly reduces or prevents the long-term predisposition of trees to decline or death caused by winter injury or by pathogens. Good site preparation without fumigation, or fumigation without careful and timely site preparation, offers only short-term benefits for replant orchard establishment and little hope for sustained high production or tree longevity. After fumigation and planting, use of post-plant nematocides in the second and third years may further delay the inevitable buildup of nematodes.



4.3 FROST / FREEZE PROTECTION

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Consistency in cropping and maintenance of fruit quality are keys to profitable peach production. Frosts and freezes can account for crop losses ranging from minor to complete. Cold-induced scarring of fruit can also produce major losses. In many cases, crops can be protected from cold damage by one or more methods. This chapter acquaints you with the various types of cold events, identifies situations in which protection is feasible, and outlines strengths and weaknesses of various control options.

As peach fruit buds progress from a fully dormant condition to bloom, they lose their ability to tolerate cold temperatures without being injured or killed. The **critical temperature** is defined as the temperature that buds, flowers, or fruits will tolerate for 30 minutes or less. Critical temperatures for various deciduous fruits have been published, and those for peaches are shown in Table 4-3-1.

Several factors can influence the actual temperature at which injury occurs. The numbers in Table 4-3-1 are only a guide. Buds on weak trees cannot tolerate the same temperatures as those from healthy trees. Conditions leading up to the cold

event influence hardiness.

Thermometers used to monitor orchard temperatures must be reliable. Use straight-tube, alcohol, minimum-registering thermometers with the scale etched on the tube. They should be placed in standard thermometer shelters, as evaporative cooling can cause lower readings on exposed thermometers. Check thermometers annually by submerging them in a slurry of ice and water to assure accuracy; water in the mix should stabilize after stirring. After frost season, store thermometers upright (bulb down) in a cool place. Watch for separations in the alcohol column.

Use a minimum of two thermometers, one in the coldest part of the orchard to help determine when to institute active frost control measures and the other outside the orchard (preferably upwind) and away from the area affected by the frost control techniques to help determine when to discontinue frost protecting. Additional thermometers placed in other parts of the orchard further aid in deciding when to frost protect. Be sure thermometers are not directly affected by heaters. *The temperature of the buds, twigs, and leaves can be 2° to 4°F lower*

TABLE 4-3-1. Critical temperatures for fruit buds of peach.

	Bud Development Stage						
	First Swelling	Calyx Green	Calyx Red	First Pink	First Bloom	Full Bloom	Post Bloom
Avg. Temp. (°F) for 10% Kill	18	21	23	25	26	27	28
Avg. Temp. (°F) for 90% Kill	1	5	9	15	21	24	25

Ballard, J. K. and E. L. Proebsting. 1978. Frost and Frost Control in Washington Orchards. Wash. State Univ. Coop. Ext. Bull. No. 634.

than the air temperature registered by a shielded thermometer; take this into account when using frost protection.

Check thermometers frequently. Record time, location, minimum temperature, and the temperature at the time of reading. Keep these records over time, they can help detect temperature trends and determine the effectiveness of frost protection measures.

Frost alarms can be effective in informing you of an approaching problem if they are correctly installed and maintained. The sensor for the alarm should be placed in a standard thermometer shelter to prevent evaporative cooling from producing a false alarm. The circuitry and the accuracy of the unit should be inspected each season to assure proper operation. Immerse the sensor in an icewater slush with at least two check thermometers to confirm reliability.

Dewpoint is the temperature at which moisture will begin to condense out of the air, forming dew. The higher the relative humidity at a given air temperature, the higher the dewpoint. When the relative humidity is 100%, the air temperature equals the dewpoint. Frostpoint is similar to dewpoint — it is the temperature at which frost just begins to form. The difference between dewpoint and frostpoint is less than 2.5°F at temperatures between 14° and 32°F, so for practical purposes these terms can be used interchangeably.

On calm nights, the dewpoint represents the lowest temperature to which the air can cool, which is due to the liberation of latent heat during the formation of dew or frost. In essence, the heat released as water condenses offsets the tendency for the air to cool, so the temperature stabilizes at the dewpoint. Dewpoint also affects the rate of air temperature decrease. *With a low dewpoint, the potential exists for a very rapid drop in temperature, sometimes several °F per hour.* Knowing the dewpoint is valuable in deciding whether or not frost protection may be needed and when to initiate active frost protection measures such as sprinkling, wind machines, or heating.

A sling psychrometer (also called a wet-bulb dry-bulb thermometer) is used to determine dewpoint

readings. This instrument is made up of a pair of thermometers mounted on a frame. A swivel handle attached to the frame allows the thermometers to be whirled. The bulb on the lower thermometer is covered with a thin muslin sock, which is wet at the time of measurement. Twirling the psychrometer affects both thermometers. The dry bulb measures air temperature. The wet bulb registers lower due to the cooling effects of evaporation on the wet sock. The difference in readings is referred to as the “wet bulb depression,” and is indicative of the relative humidity and dewpoint. Wet bulb temperatures should not be relied on to determine when to begin frost protecting, as the readings may be too low. Refer to Table 4-3-2 to determine relative humidity and to Table 4-3-3 to determine dewpoint by the use of a sling psychrometer. Conversion charts and slide rulers for conversion are available from many of the same sources that sell the sling psychrometers.

To obtain reliable readings from a sling psychrometer, the instrument must be kept in good condition. The sock on the wet bulb thermometer should be replaced periodically because impurities left on it by evaporation can cause inaccurate readings.

Advective freezes and radiation frosts are the two types of cold events that threaten fruit crops. Many nights will have characteristics of both types.

An **advective freeze** occurs when an arctic cold mass moves into a region. During the day, an advective freeze is cold, with temperatures seldom getting above 50°F; air is often dry and windy. These conditions persist into the night, with temperatures getting much colder. Temperature inversions are usually weak. These conditions generally affect a fairly large area and may persist for several days. The wind and temperatures, which may be quite low, combine to make most frost protection practices ineffective. Advective freezes are normal in winter but may also occur in spring.

A **radiation frost** is generally fairly localized and of a shorter duration than an advective freeze. Days preceding radiation frosts are clear, calm, and fairly warm. At night, skies remain clear, the winds stay calm, and temperatures drop drastically. At night, heat absorbed by the ground during the

TABLE 4-3-2. Determining the relative humidity from wet-bulb and dry-bulb thermometers.

Dry-Bulb Temp. (°F)	Difference Between Readings of the Wet-Bulb and the Dry-Bulb Thermometers (Degrees Fahrenheit)																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	0	70	40	10																
5	5	75	50	26	4															
10	10	80	60	40	22	4														
15	15	84	68	52	34	20	5													
20	20	6	72	59	46	33	20	7												
21	86	73	60	48	34	22	11													
22	87	74	61	50	36	25	13	2												
23	87	75	62	51	38	27	16	4												
24	88	76	64	53	41	30	19	8												
25	88	77	65	54	42	32	22	11												
26	88	77	66	55	44	34	24	14	4											
27	88	78	67	56	46	36	26	16	6											
28	89	78	68	57	48	37	28	18	9											
29	89	78	69	58	49	39	30	20												
30	89	80	70	60	51	41	32	23	14	6										
31	90	80	71	61	52	43	34	26	17	8										
32	90	81	72	62	53	44	36	27	19	10										
33	90	82	73	63	55	46	38	29	21	13	5									
34	90	82	74	65	56	48	40	32	24	16	8									
35	90	82	73	66	58	50	42	34	26	18	10	4								
36	91	82	74	65	59	51	44	36	28	20	13	6								
37	91	83	75	66	58	53	45	38	30	22	16	8								
38	91	83	75	67	59	51	47	39	32	24	17	10	4							
39	91	83	76	68	60	53	46	41	34	27	20	13	6							
40	92	84	77	68	61	53	47	39	36	28	22	15	8							
41	92	84	77	69	62	54	47	40	31	31	24	17	11	5						
42	92	84	77	70	62	55	48	41	34	28	26	19	13	6						
43	93	84	78	70	63	56	49	43	36	29	23	22	15	9	3					
44	93	85	78	71	64	57	50	44	37	31	24	18	17	12	5					
45	93	86	78	72	65	58	57	45	39	32	26	20	14	13	8	3				
46	93	86	79	72	65	58	53	46	40	33	27	22	16	11	11	5				
47	93	86	79	72	66	59	54	47	41	35	29	23	17	12	7	2				
48	93	86	80	73	67	60	54	48	42	36	30	24	19	14	8	4	4			
49	93	86	80	74	67	61	55	49	43	38	32	26	20	16	10	5	2			
50	93	87	81	75	68	62	56	50	45	39	33	28	23	18	13	7	3			

day is radiated into the atmosphere. Air in contact with the ground is cooled, causing it to be heavier than the warm air above. This cold air drifts along the ground to the lowest areas. Usually, it is coldest just prior to sunrise. Active frost control techniques can be successfully employed during a radiation frost. Radiation frosts often have strong inversions.

An **inversion** is a layer of warm air floating over a layer of colder air next to the surface of the ground. During daylight hours, the earth absorbs heat from the sun. Air in contact with the ground is heated; therefore, the warmest air is at ground

level. Air temperatures get progressively cooler with increasing elevation above-ground. On a calm, clear night, the ground is cooled by radiant heat loss into the sky. The air near the ground is colder than the air higher off the ground (exactly the opposite of what may be observed during the day). At some height, this increasing temperature trend reverses itself and temperatures decrease with increasing elevation. This point is called the height of the inversion.

The strength of the inversion (weak vs. strong) refers to the temperature differential at 50 to 60

TABLE 4-3-3. Determining dewpoint using air temperature (dry-bulb reading) and relative humidity.

Dry-Bulb Temp ° F	Percent Relative Humidity																		
	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
5	-35	-30	-25	-21	-17	-14	-12	-10	-8	-6	-5	-4	-2	-1	1	2	3	4	5
10	-31	-25	-20	-16	-13	-10	-7	-5	-3	-2	0	2	3	4	5	7	8	9	10
15	-28	-21	-16	-12	-8	-5	-3	-1	1	3	5	6	8	9	10	12	13	14	15
20	-24	-16	-11	-8	-4	-2	2	4	6	8	10	11	13	14	15	16	18	19	20
25	-20	-15	-8	-4	0	3	6	8	10	12	15	16	18	19	20	21	23	24	25
30	-15	-9	-3	2	5	8	11	13	15	17	20	22	23	24	25	27	28	29	30
35	-12	-5	1	5	9	12	15	18	20	22	24	26	27	28	30	32	33	34	35
40	-7	0	5	9	14	16	19	22	24	26	28	29	31	33	35	36	38	39	40
45	-4	3	9	13	17	20	23	25	28	30	32	34	36	38	39	41	43	44	45
50	-1	7	13	17	21	24	27	30	32	34	37	39	41	42	44	45	47	49	50

feet above-ground versus the temperature three to five feet above-ground. The temperature differential at this height has a pronounced effect on the performance of ground heaters and wind machines.

As heated air rises, it gets cooler. The height at which the airstream temperature reaches the same temperature as its surroundings is referred to as the **ceiling**. At this point, the upward motion of the airstream stops. The **ceiling corresponds to the height of the inversion**. Smoke from a small fire rises until it reaches the ceiling, at which point it stops rising and spreads out. The ceiling is generally low on nights following warm days. The volume of the air to be heated and the amount of fuel needed to heat it are relatively small. Heating and/or the use of wind machines may be quite successful in such conditions. A high ceiling (following cold days) means that there is a lot of air to be heated and that the amount of fuel needed to heat it will be high.

Winds mix colder air at ground level with warmer air above it. As long as the wind stirs the air, the temperature drop will be slowed. Often winds decrease at night, which predisposes more rapid temperature drops. When a wind is strong

enough to thoroughly mix all the air in and above trees, the temperature in an orchard can actually rise. Wind machines are employed to mix the air and hopefully keep it above the critical temperature.

CLOUDS — YES, SMOKE — NO

Heat lost from the orchard is radiated in long wavelengths that cannot entirely pass through the water vapor of clouds. Clouds, if low enough and of great enough density, absorb radiant heat from the ground and re-radiate it back into the orchard. Clouds passing over an orchard on a frosty night may stop the drop in temperature and may even cause a temperature increase. Small, isolated clouds and cirrus clouds do not impede radiation of heat from the orchard floor.

Although cloud cover helps retain heat, smoke does not effectively maintain warmth. Heat radiated from the orchard in long wavelengths will pass through smoke, but short wavelength radiation from the sun does not. Therefore, the use of smudge pots or burning tires to produce smoke as well as heat does not work. Radiated ground heat escapes through the smoke at night and the smoke prevents heat

from the sun from reaching the ground during the day, which delays the warming of the orchard in the morning and necessitates longer frost protection times.

Passive and active frost controls are the two basic categories of frost protection.

Passive control involves elements that cannot be changed or are difficult to change once they are in place. Site selection and development, variety, pruning and training, tree health, and orchard floor management are all factors that have a passive impact on frost susceptibility. Employing passive frost control concepts may lessen the need for active controls, reduce the frequency of using the active controls, or at least increase the effectiveness of active controls. Passive controls do not constitute an extra expense in orchard development and maintenance, plus they are sound horticultural practices from other standpoints.

Elevation in regard to the immediate surroundings may offer protection during a radiation frost event. As a rule of thumb, for each 100 feet increase in elevation during a radiation frost event, expect an increase of 5° to 10°F. Thus, an orchard located in an elevated site may not experience frost damage, whereas serious injury may occur in an orchard situated at a lower site. Locating the orchard on a slope instead of a hilltop may be preferred, as winds and freeze damage may be more likely to occur on a hilltop. An elevated site may experience decreased disease pressure, as fogs may settle below the orchard, which creates a less favorable environment for disease development.

How far down a slope to plant depends on how much air drainage occurs. If air readily drains from a site, it is feasible to crop at lower elevations.

An important part of orchard site preparation includes the removal of any blockages to air drainage out of the orchard. Even if the orchard is planted on an elevated site, the presence of woodlands, hedgerows, or overgrown fencerows on the slope below the orchard can slow air drainage out of the site and create a frost pocket above the basal part of the slope.

Direction of slope can have some effect on frost

problems. Trees on a north-facing slope may be somewhat delayed in their development in spring, thus reducing their vulnerability to frost. Trees on a south to southwestern slope will be most advanced.

Cultivars showing less hardiness in regard to frost should be planted further up the slope than more hardy cultivars, to give the tender cultivars the extra protection afforded by increased elevation.

Orchard floor management practices can impact on frost problems encountered in the orchard. The ideal orchard floor from a frost protection standpoint is firm, bare, moist soil, without any vegetation. This type of orchard floor absorbs more heat during the day than other floor management plans. And bare, compacted soil will re-radiate heat back into the air over a longer period at night, which offers an extra couple of degrees protection in early morning just before sunrise when temperatures are often at their lowest point. Dry, freshly tilled soil or tall grass and weeds offer the poorest floor management plan from a frost control standpoint.

Because many orchards are on uneven land, cultivating the entire orchard floor soil to control vegetation is unacceptable because of associated problems with soil erosion, reduced tree health, and poor orchard trafficability. The ideal orchard floor management plan for most sites is a continuous strip of bare soil under the trees with closely mowed sod between rows and around the orchard. The wider the vegetation-free strip the better. Close mowing in and around the orchard is an integral part of a frost protection plan. Tall grasses and/or weeds in and around the orchard will interfere with good air drainage out of the site, which increases the potential for frost in the orchard.

Although air drainage out of the orchard may be better where rows run up and down the slope, this is seldom practical. Increased problems with soil erosion in the vegetation-free site, the inherent difficulty of maintaining constant tractor speed on slopes and resultant lack of precision in making pesticide applications up and down hills, and the difficulty of designing and installing an irrigation system, all combine to make orienting tree rows across slopes a far better way to set an orchard.

Fruit buds on healthy trees are more capable of tolerating cold stresses than those on weak trees.

Active frost control. More assertive frost control techniques are said to be active. They should be used to supplement the protection offered by passive controls. They include heat, wind, heat plus wind, and irrigation. When selecting an active frost control system, choose one that is reliable and easily implemented. Keep in mind that these systems will be employed under adverse conditions. It will be cold, dark, and late at night when frost protection is needed. In the case of irrigation for frost protection, the price in crop damage, if the system should break down, is high, often worse than if nothing is done. Therefore, always test systems in advance. Anticipate potential problem areas and have spare parts and equipment on hand. These systems are not inexpensive; however, they can be an excellent investment. Proper operation of your frost control system is imperative; consult with knowledgeable individuals for design, installation, and operation.

Heaters may be used to warm the air under the inversion layer. They should be capable of raising the temperature 7°F. The success of this practice depends on the height and strength of the inversion and whether or not there is any wind. Many small heat sources are more effective than a few large heat sources. In fact, a big fire can readily puncture the inversion, resulting in a cooling of the air below the inversion. The number of heaters needed per acre may vary from about 20 to 40. The actual number depends on the energy output per heater and the orchard design. High-density orchards need more heaters than conventional plantings.

Several different types of heating systems have been used, and there are advantages and disadvantages to each.

Burning wood and tires has been used with varying degrees of success. Although they are inexpensive, these materials are very labor intensive. They are hard to light and to keep going, they are messy, and they can spread to dry grass and weeds on the orchard floor if not closely monitored.

Oil-fired heaters range from self-contained units

such as return stack, large cone, and short stack heaters to pressurized oil systems where the burners are all connected by plastic fuel delivery lines. The self-contained units offer a low initial cost. They are easily moved and the number of them used per acre can be increased or decreased quickly. Lighting them can require substantial labor and time — a disadvantage when temperatures are falling rapidly.

Pressurized oil systems use fuel (generally #2 diesel fuel) delivered to the burners through plastic lines from a central distribution point. The burners feature automatic electric ignition at each unit. The advantages of this system include efficiency of the burners and the reduction of labor needed to light and operate the burners. Disadvantages include lack of flexibility in the number of burners per acre, more places for problems to occur (lines, filters, pumps, igniters), the need for a check valve on each heater for quick shutdown, and the increased cost of the system.

Gas heaters use propane or natural gas where available. Propane is the most expensive fuel on a heat unit basis, and propane may present additional problems in delivery to the orchard and in handling. An on-farm propane storage tank should be big enough to allow for two consecutive nights of use.

Natural gas is easiest to use. However, it is unlikely that it will be available at many orchards. With it, no storage tanks, pumps, or filters are needed. Heaters generally require a minimum of maintenance.

The objective of heating is to distribute heat to keep all areas of the orchard above the critical temperature. When firing up the system, light the border heaters first, starting with those on the windward or lower parts of the orchard. For individual heater systems, light every other heater. For piped pressure systems, light every other row. Light additional heaters as needed.

The appropriate index to indicate when to light heaters is air temperature. Light heaters when the air temperature is 2° to 4°F above the critical temperature for crop damage. Keep in mind that a low dewpoint means temperatures drop rapidly, so do not wait as long to start the heaters as when the dewpoint is high. Base the time to turn off

heaters on a thermometer located outside of the heated area.

Overtree wind machines work by mixing warm air in the inversion with cold air in the orchard. On nights when inversions are weak or above the height of the wind machines, no benefit will be derived from running them.

Heat-generating wind machines are less efficient than wind machines alone. The added heat makes the air more buoyant and causes it to rise above treetops sooner. Wind machines supplemented with heat among trees in the outer perimeter of the machine range will help some when inversions are weak.

If an orchard site consistently shows an inversion with temperatures at least 3°F warmer at the 30 to 50 feet height as compared to the temperature among the trees, wind machines may be worthwhile.

The effective range of wind machines varies from 6 to 10 acres. The coverage area depends on the site, size of the machine, and the proximity of other overtree machines. Two or more machines tend to reinforce the effectiveness of each other.

Helicopters may be effective when inversions are strong. The helicopter should be flown in a slow pattern over the orchard in the inversion. It will mix warm air in the inversion with cold air in the orchard. Depending on the site and the strength of the inversion, a single helicopter may be used to protect upwards of 40 acres. Arrangements to secure the helicopter should be made well in advance. On nights where use is highly likely, the helicopter should be on standby at the orchard site. Fuel for the helicopter should be available so the pilot will not have to leave the orchard site to refuel. Be sure pilots are aware of hazards such as power lines, rock ledges, tall trees, and so on prior to flying at night.

Overtree sprinklers are practical to use for frost protection. However, their use is very exacting. This frost control method has more risk associated with it than other methods, but it also offers some advantages that other frost control methods do not possess; for example, their operating costs, convenience, and cleanliness as compared to

other types of active frost protection.

As water cools, it gives up heat. One British Thermal Unit (BTU) of heat will be removed from each pound of water for each degree Fahrenheit of temperature reduction. Heat will be given up at this rate until the temperature of the water reaches 32°F. Water turning to ice (called the “latent heat of fusion”) liberates 144 BTUs per pound. This heat energy is available to prevent plant tissue from dropping below 31.5°F. As long as a film of water is maintained by continuous application, the temperature of the plant tissue will remain at or above 31.5°F even though a layer of ice is being steadily formed.

If water application stops, evaporative cooling often cools both the ice and the plant even lower than the surrounding air. Ice is a very poor insulator. **It is imperative that a continuously maintained film of water is sustained as long as the temperature is low enough to freeze ice or until the ice begins to melt rapidly after dawn.** Over time, the layer of ice can build up to the point that the excess weight can damage trees. Training trees to hold a lot of weight throughout their life and having the trees pruned prior to the time that the irrigation system will be used is important in minimizing the potential for tree damage.

For protection down to 20°F, an application rate of between 0.15 and 0.20 inches of water an hour is needed, depending on the dewpoint and wind speed. Although an application rate of 0.15 inches should provide protection down to 20°F, a 0.20 inch per hour application rate is better on the upwind side of the orchard where evaporative cooling rates are highest. Large volumes of water are required, for example:

- 0.15 inches/hour = 67.3 gallons per minute or 4,038 gallons per hour. This volume is the equivalent of an accumulation of 1-1/2 inches of water in a 10-hour run.
- 0.20 inches/hour = 90 gallons per minute or 5,400 gallons per hour.

The water supply should be adequate to run continuously 10 hours a night for at least three

consecutive nights. If pumping from a pond, the size and the recharge capacity of the pond are important. If pumping from a stream, the reliability of the stream and the flow rate are similarly important.

To give good frost protection, the water must be distributed all over the orchard. A system designed for drought control is generally inadequate for frost protection. When the system is started, the pumps and the mains must be large enough to allow the entire system to be run at one time.

Sprinkler heads should rotate at least once every minute to maintain a water film over the plant tissue and ice at all times. Two revolutions per minute provide more control than one. Sprinkler heads should be constructed to prevent ice buildup around the activator spring.

The site often dictates the spacing of sprinkler heads. Wind velocity and direction, tree spacing and arrangement, and the direction of traffic pattern should all be considered. The maximum distance between sprinklers is governed by the diameter of the sprinkler discharge pattern and wind velocity. In general, the maximum spacing between sprinklers should not exceed 50 percent of the wetted diameter.

Overhead irrigation frost control systems should be started before the temperature of a shielded thermometer drops to 33°F in the coldest part of the orchard. Starting at a lower temperature is risky because the temperature in the sprinkled area will drop during the first few minutes of operation due to evaporative cooling and may hasten the drop below the critical temperature. If the dewpoint is

low, start the frost control sooner, as temperatures will drop rapidly, making it difficult to get the system running before the critical temperature is reached.

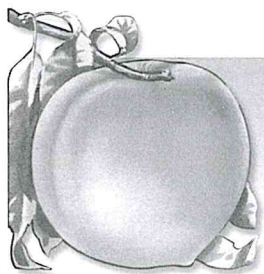
End sprinkling after sunup when the rising temperature reaches 33°F outside the treated area and the ice is beginning to melt. If the wind is blowing, do not shut down until 35°F. It is not necessary to wait until the ice is all gone before shutting the system down.

Bloom delay has been studied for many years. A fall application of ethephon can delay bud break in spring. Research has demonstrated numerous problems with bloom delay. If the rates are too high, fruit buds may be killed. In extreme cases, limbs and even entire trees could be killed. The number of days delay has not been constant from year to year. Ethephon is not labeled for bloom delay.

Using higher rates and multiple applications of dormant oil during winter can slow respiration rates in trees and delay bud break. The number of days delay has been inconsistent. Additional research is being conducted to improve the reliability of the treatments. Dormant oils are not labeled for bloom delay at this time.

Overtree sprinkling during the winter months can delay bud break. Once the chilling requirement of the tree has been met and when air temperatures get above 50°F, evaporative cooling from the sprinkling will slow bud development. Problems with tree health and in working the orchard can occur as a result of the application of large amounts of water.





4.4 ROOTSTOCKS

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Economic viability of a tree fruit production enterprise is linked directly to orchard productivity and management efficiency. Optimal levels of productivity and efficiency require tree survival, managed vigor, and good marketable yields over the expected lifespan of the orchard. The grower's choice of rootstock is quite important when peaches, nectarines, or plums are grown on soils having high bulk density, parasitic nematodes, root rot fungal pathogens, or other soil or replant problems. In the southeastern United States, where one or more of these conditions is present in most orchard sites, peach tree survival and growth can be significantly improved by selecting the appropriate rootstock. Peach production efficiency in the Southeast has been limited by the absence of rootstocks that offer moderate vigor or tolerance to undesirable soil properties, site characteristics, and soil-borne pathogens. As good orchard sites become fewer and chemical controls more costly or unavailable, rootstocks that better address these site and vigor problems will become a crucial need.

New rootstocks for peaches [*Prunus persica* (L.) Batsch] are being introduced through commercial nurseries. Many of these rootstocks are complex vegetatively propagated *Prunus* L. hybrids. Experience has shown that extensive testing is critical to avoid commercial failures from rootstocks that prove poorly adapted to local climatic and soil conditions. In addition, putative resistance of new rootstocks to soil diseases and other pathogens has sometimes failed when planted in other production regions.

BIOTIC AND ABIOTIC SOIL FACTORS AFFECTING PEACH ROOTSTOCKS

Parasitic Nematodes

Several nematode species successfully attack peach roots and reduce peach growth and survival. Four nematodes are recognized as injurious to peach trees in the Southeast: ring (*Mesocriconema xenoplax* (Raski) Luc & Raski), root-knot (primarily *Meloidogyne incognita* (Kofoid & White) Chitwood and *M. javanica* (Treub) Chitwood), lesion (*Pratylenchus vulnus* Allen & Jensen), and dagger (*Xiphenema americanum* Cobb).

Rootstock response to nematodes can be categorized as immune, resistant, tolerant, or susceptible. For a specific nematode species, immune or resistant rootstocks are poor or non-hosts for nematode survival and reproduction and are unaffected by nematode feeding. Tolerant rootstocks are fair to good hosts for a specific nematode, but nematode reproduction and feeding does not significantly alter the rootstock's ability to support scion survival, growth, and productivity. Rootstocks susceptible to a specific nematode are good hosts for nematode reproduction, and nematode feeding impairs tree survival, growth, and fruiting.

Ring nematode has been directly linked to peach tree short life (PTSL) syndrome in the Southeast. Many of the newest rootstocks have not been tested for reaction to ring nematode. However, older (1980s) rootstock introductions such as the French peach seedling rootstocks Montclar, Rubira, GF 305, and Higama, and the plum hybrids Ishtara

and Myran are good hosts for ring nematode and are susceptible to PTSL. No peach rootstock has survived better in field tests in South Carolina and Georgia than the regionally developed Guardian Brand BY520-9. Guardian is more tolerant to ring nematode and PTSL than Lovell or Halford; whereas Nemaguard and Nemared are highly susceptible to both ring nematode and PTSL. Bailey, another commercial rootstock, is also susceptible to PTSL.

Root-knot nematodes, which cause serious growth reduction in peach trees, are present in sandy soils throughout most of the region's coastal plains and sandhills production areas. These soils have two species of root-knot nematode (*M. incognita* and the less common *M. javanica*), as well as a number of races within each species. Several peach rootstocks, including Shalil, Yunnan, and Okinawa, have been introduced for root-knot nematode resistance in the United States in the twentieth century. All of these rootstocks either were not resistant to *M. javanica* or had other problems and eventually were replaced by domestically developed rootstocks such as Nemaguard, Nemared, Flordaguard, and Guardian BY520-9. However, with the exception of Guardian, each of these root-knot resistant rootstocks is susceptible to ring nematode and PTSL (Table 4-4-1). In contrast, Lovell and Halford are highly susceptible to both root-knot species and should not be planted on sites having detectable numbers of root-knot nematodes. However, except for Guardian, Lovell and Halford survive better than the root-knot resistant rootstocks on ring nematode sites.

Lesion (*Pratylenchus vulnus*) and dagger (*Xiphenema*

americanum) nematodes are also peach pests in the eastern United States. Lesion nematodes can significantly reduce tree growth and fruit production if not controlled. Rootstocks tolerant to *P. vulnus* in Europe, such as Rubira, Penta, Tetra, Torinel, and P.S.B2, have been evaluated in the eastern United States. These European stocks have shown little promise. In greenhouse studies on resistance to lesion nematode, Bailey and Guardian BY520-9 were less susceptible than many of the European rootstocks tested, though none were resistant. However, little research has been done on the impact of lesion nematode on peach in the Southeast because ring and root-knot nematodes are more serious problems.

The dagger nematode is not common in southeastern peaches but does occur, especially in the piedmont peach production regions. When feeding on peach roots, dagger nematode serves as the vector for tomato ringspot virus (ToRSV), which causes stem pitting. Because many weed species such as dandelions (*Taraxacum officinale* Weber) are hosts for ToRSV, dagger nematode resistance in rootstocks is the only practical way to prevent infection. Peach seedling rootstocks are not resistant to dagger nematodes; therefore, new non-peach rootstocks need to be evaluated as to their susceptibility to the nematode or the virus. Some cherry plum (*P. cerasifera*) selections appear to be less sensitive to ToRSV. Thus, the clonal rootstocks Mr.S. 2/5 and Mr.S. 2/8 (both *P. cerasifera*), Krymsk VVA-1 (*P. cerasifera* x *P. tomentosa* Thunb.) and Krymsk VSV-1 (*P. incana* (Pall.) Batsch x *P. cerasifera*), and Adara (*P. cerasifera*) may offer some tolerance. However, none of these rootstocks have been tested in North America for

TABLE 4-4-1. Commercial rootstocks planted in the southeastern United States and their tolerance to nematodes, short life, and oak root rot.

Rootstock Cultivar	Ring nematode tolerance	Peach tree short life tolerance	Root-knot resistance	Oak root rot resistance
Lovell	fair	fair-good	susceptible	susceptible
Halford	fair	fair-good	susceptible	susceptible
Nemaguard	poor	poor	resistant	susceptible
Guardian	fair-good	very good-excellent	resistant	susceptible

ToRSV resistance. Buying virus-free trees, tested for ToRSV, is recommended as the best option to help prevent introduction of ToRSV to your orchard site.

Soil Texture and Pathogens

Peach rootstocks are not well adapted to poorly drained or heavy clay soils. On these soils, peach rootstocks are at risk of becoming infected with fungi (*Phytophthora* de Bary) that cause crown rot. Similarly, all peach rootstocks are susceptible to the oak root rot fungus (*Armillaria mellea* (Vahl: Fr.) P. Kumm. and *A. tabescens* (Scop.) Emel) if it is present (Table 4-4-1), regardless of soil texture or drainage. Both organisms are difficult to control and eradicate; therefore, genetic resistance to these pathogens would be highly desirable in rootstocks. Research to develop an *Armillaria* (Fr.:Fr.) Stauder resistant rootstock at USDA, Byron, Georgia, by hybridizing native plums with other species shows promise, but no rootstocks have yet been released.

Many European rootstocks recently introduced to the United States are listed as tolerant of waterlogging. These rootstocks include Jaspi, Julior, Penta, Tetra, Mr.S. 2/5, Barrier 1, Adesoto 101, Adara, Montizo, and Krymsk VVA-1 and VSV-1. However, because the season of waterlogging is not specified in release notices, it is not known whether these rootstocks are tolerant of dormant or growing season wet soil conditions. Many of these rootstocks were developed in Mediterranean climates that receive their rainfall in the winter. Because waterlogging can also occur during the growing season in the southeastern United States, these rootstocks need further testing before commercial release.

These rootstocks and other European varieties are also listed as tolerant of replant sites and soil diseases. However, specific soil diseases usually are not identified. Ishtara and Myran were reported to be resistant or tolerant to oak root rot (*A. mellea*) in France. Observations in the southeastern United States show that these rootstocks are susceptible to *A. tabescens* and may not be resistant to the endemic fungal soil pathogens. Furthermore, Jaspi has been very susceptible to bacterial canker in South Carolina and Georgia. These preliminary observations underscore the

need for thorough, widespread field-testing of new "disease tolerant" rootstocks before they are planted commercially.

Currently, no peach rootstock planted in the Southeast is tolerant to *A. tabescens* or waterlogging. Site selection and cultural practices must be carefully considered when using commercial peach rootstocks on problem soils.

ROOTSTOCKS FOR VIGOR CONTROL

Peach seedling rootstocks, including brachytic dwarfs, rarely reduce scion vigor more than 10% to 15%. Size control of peaches through rootstocks using other *Prunus* species has not been satisfactorily achieved due to incompatibility or poor tree vigor. Good dwarfing rootstocks for peach would reduce vigor, be graft compatible, and give good fruit production without reduction of fruit size and quality.

Imported European rootstocks listed as mildly dwarfing (approximate percent of peach standard) include Ishtara (70%), Julior (70%), Rubira (90%), Tetra (90%), Mr.S. 2/5 (90%), and Adesoto 101 (80%). Semi-dwarfing rootstocks include PumiSelect (60%), Sirio (60%), and Krymsk VSV-1 (50%) and VVA-1 (40%). The degree of dwarfing with these rootstocks varies with climate, soil type, and site history. Of these new rootstocks, trees on Ishtara have been highly susceptible to bacterial canker in South Carolina, Adesoto 101 root suckers extensively, and PumiSelect has not survived well on heavy soils in South Carolina. Current peach rootstocks used in the southeastern states are all vigorous, with Nemaguard, Flordaguard, and Guardian being more vigorous than Lovell or Halford.

FUTURE COMMERCIAL OUTLOOK

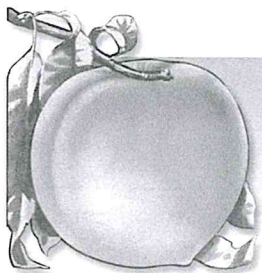
Better peach rootstocks are being developed, but the time from initial testing to commercial production takes a number of years. New rootstocks originating from current breeding programs will probably be complex species hybrids that must be propagated vegetatively, which is a particular likelihood for rootstocks that will be resistant to

oak root rot (*Armillaria* sp.), *Phytophthora* sp., waterlogging, and some ectoparasitic nematodes. Micropropagation from tissue culture explants has been employed in western Europe to mass produce unique hybrid rootstocks, and this technology is now being used by a few commercial nurseries in the United States.

Other factors that may delay the release of new rootstocks into the United States are patent laws and licensing agreements that must be negotiated between government agencies, breeders, nurseries, and grower groups. Despite these problems, new rootstocks are being tested through regional and national trials such as the NC-140 regional project, which evaluates new rootstocks for stone and pome fruits across the United States and Canada. This project, in conjunction with new screening methods and extensive cooperation among researchers, is decreasing the time to evaluate future rootstock selections for fruit growers.

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4.5 VARIETIES

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Variety selection is one of the most critical choices a peach grower can make. Culture and management decisions are of limited value in compensating for an ill-suited variety. Varieties need to be chosen based on climate as well as anticipated marketing window. Although hundreds of varieties have been released in the United States in the last 50 years, most are no longer or were never grown much, and usually for good reason. The trend in peach breeding has been toward more firmness, more red color, and shorter fuzz, which improve eye appeal. However, the selection process has not necessarily led to increased flavor. All varieties have strong and weak points, so a grower must match the variety to his needs. Peach growers should check multiple sources to find out which varieties are likely to best fit their needs. Sources of information include neighbor growers, extension workers, breeders, and nurserymen. Table 4-5-1 lists some of the varieties popular at the time of writing. This list will likely be very different in 10 years.

CHILLING REQUIREMENTS AND CLIMATIC ADAPTATION

This section is less pertinent to cooler, northern regions of the Southeast or the United States. In these areas, amount of chilling is less an issue than winter bud hardiness.

Peach varieties for southern climates are bred to bloom during seasonal time windows to fit the particular climate. During the winter, flower and leaf buds keep track of the amount of cold weather experienced. When buds have received their pre-programmed amount of cold, they respond to warm weather and bloom. This characteristic is

called chilling requirement and is commonly expressed in “chill hours” or sometimes “chill units.” If chill requirement is met early in winter, peaches bloom early and may be killed by later frosts. If the amount of chilling by spring is inadequate, buds develop abnormally and bloom sporadically or, in more severe cases, simply dry up and fall off. In severely under-chilled situations, few fruit are set and only the terminal and a few lateral buds break, leading to a weak tree and a poor crop again the next year. Although the chilling process is not fully understood, the following paragraphs explain the current theory.

Chilling Requirement

The first widely used approach to keeping track of chilling effects on peach buds was that of John Weinberger, former breeder at USDA-ARS in Fort Valley, Georgia. He grouped peach varieties relative to their ability to bloom “normally” and set a crop in winters with varying durations of temperatures below 45°F. A “750 hour” peach needed at least that many hours below 45°F before February 15 to bloom normally. Although Weinberger’s system was useful to gauge the effect of winter on buds, he noted several cases in which the numbers did not match results in the orchard. This system is still used in the Southeast because it is easy to calculate; varieties are ranked relative to their chill requirement, which indicates areas of adaptation. Generally peaches with the same chill requirement bloom together.

In other areas, Weinberger’s system was less useful. E. Arlo Richardson and co-workers developed the “Utah” model (actually several versions), which refined the effects of specific chilling temperatures over a broader range. They defined chilling with a range from 32° to 58°F, with an optimum of

43°F. One hour at 43° gave one “chill unit,” while one hour at a higher or lower temperature resulted in a partial unit. Below 32°F had no effect on chilling, and above 58°F resulted in erasing some of the previous chilling. They later included the effects of heat above 40°F to bring the fully chilled bud into bloom. This model fits bloom data in Utah and other cold climates, but it is a poorer fit in warmer climates, partly because negation by warm temperatures was unlimited.

At Byron, Georgia, the cumulative Weinberger hours and Richardson units are similar in many years. In winters with long spells below freezing, Weinberger hours are higher than Richardson units. In contrast, when winter temperatures between 45° and 60°F predominate, accumulation of Richardson units will outpace accrual of Weinberger hours. Although the Utah model is probably closer to measuring the real effects of temperature on peach buds, it needs modification to accurately predict bloom in the Southeast.

For locations where chill hour accumulations are not available, particularly in warmer production areas, chill can also be estimated by the following formula:

$$\text{Seasonal Chill Hours} = 100 * (18.5 - t)$$

where t = mean temperature (°C) of January or the coldest month. The mean monthly temperature is the average of the daily highs and lows for the month.

It appears that each shoot of a given variety has buds that vary widely in “chill requirement,” perhaps by several hundred hours or more. This range in chill response would explain why bloom is more concentrated in high-chilling years or in northern climates. The length or range of time in bloom is an indication of how adequately trees were chilled. Each added week of chill increases the final percentage of flowers that will bloom, as the proportion of buds that received satisfactory chilling increases. These additional flowers will fall into sync more or less with the initial ones if temperatures are cool enough to promote chilling but not warm enough to provide heat units. As a result, increased chilling contracts the bloom period. If additional chill is interspersed with long warm spells, the first wave of blooms will open while others are tight, resulting

in the split bloom seen sometimes in the South.

Generally the first flowers to develop will be those toward the end of shorter horizontal twigs. Flowers on vigorous upright wood typically bloom later.

In low-chill years, growers can prune to favor shorter, flatter, less vigorous wood that tends to have buds with a lower chill requirement. In high chill years, which tend to have early bloom dates, growers can select a higher proportion of more upright, vigorous wood to slightly delay bloom and perhaps avoid some late frost damage.

Recommended Varieties

Ideally, a well-adapted variety will bloom in the spring after risk of frost and crop reliably every year. Unfortunately, southeastern winters are quite variable, so that the amount of chilling weather varies greatly from year to year, making it impossible to select a single variety that blooms late in high-chilling years while also receiving adequate chill in low-chilling years. Average chilling at Byron by February 15 is nearly 1,100 hours, but the range is 650-1,600. Growers are advised to spread their risks by planting several varieties with different chill requirements for a given ripening date. Current and historical chilling hours for locations in Georgia are available at <http://www.georgiaweather.net>.

In general, lower coastal plain growers of the Southeast should choose varieties within a chill range of 350 to 650 hours. For middle Georgia and comparable areas, 650 to 950 hours is optimum. North Georgia piedmont and mountain regions will find 850 hours and up most likely to do well. Spring bud hardiness is probably not related to mid-winter hardiness, but generally speaking, later bloom reduces loss from spring frost. Because the high-chilling varieties often come from northern breeding programs, chances are they also have higher winter bud hardiness and will stay dormant longer in the southern climates, increasing the chances of getting a crop. On the other hand, as a variety is moved south, or to areas with less chilling, there is often an increase in bulging sutures and tips, with uneven firmness, sometimes to the point of the fruit being unmarketable. Fruit shape and firmness are often poorer in low-chilling years.

Pollination

Nearly all modern peach varieties are self-fertile and thus can pollinate themselves. Bees will increase fruit set and may be worth placing in the orchard in years where set is a problem, as wild bee populations have declined. The only common exceptions to self-fertility are Delta and J.H. Hale, which require another nearby variety with a similar bloom time for cross pollination.

Disease Resistance

Some peach varieties such as Clayton and Sentinel are relatively resistant to bacterial spot and only show symptoms under severe disease pressure. Other varieties such as O'Henry, Elegant Lady, and other California varieties are highly susceptible to bacterial spot and may be defoliated by the disease if left unprotected. Unfortunately, some of the most spot resistant varieties bear fruit that are no longer competitive in the market due to inadequate firmness or red color. Many varieties have a moderate bacterial spot resistance that will appear resistant in some years and locations, but not others. California varieties may also be more susceptible to cracking due to rain and to brown rot, making them more difficult to grow successfully in the Southeast.

MARKET WINDOW

Fruit Type

Most commercial peaches grown in the eastern states are yellow-fleshed freestones, except for the early season varieties, which are mostly clingstones. Freestone peaches have melting flesh that becomes soft and juicy as it ripens. Retail and wholesale markets have grown accustomed to yellow, melting-fleshed peaches. Some of the peaches grown in California are used for canning; these have a more resilient flesh texture, known as non-melting because they stay firm as they ripen. Non-melting peaches are suited to canning because the flesh stays intact during processing. Some of the newer fresh market varieties such as Springprince, Gulfprince, and Crimson Lady also have non-melting flesh. All non-melting peaches so far are clingstone, which is not a problem for early season fruit because all are more or less clingstone. Although there are a few mid to late season clingstone peach varieties available for fresh market

use, it is not clear how well they are accepted by buyers and consumers accustomed to freestones at that time of the season. However, many popular late season nectarines are clingstones. Non-melting flesh improves the firmness and eating quality in the early season if the fruit is left on the tree longer. However, non-melting varieties may develop off-flavors if allowed to over-ripen on the tree.

In recent years, growers in California have planted white-fleshed peaches, initially for the Pacific Rim export market. More white-fleshed peaches are showing up in domestic markets. The new white varieties are mostly low-acid types, in contrast to most yellow peaches and the white varieties of years past such as Georgia Belle.

Generally, the newer varieties are much firmer and with redder skin than the old ones. The low-acid flavor may seem bland to people used to standard peaches, but are often preferred in Asian and some Hispanic communities. One advantage of low-acid fruit is that there is little unripe (green) flavor so fruit can be eaten crisp, and time of picking is less critical to the ultimate flavor. The newest wave of peach varieties from California are low-acid yellow-fleshed peaches.

Peaches grown for long-distance shipping must be firmer than those sold locally. For local sales, size and flavor often are more critical than appearance or firmness. Although there are minor differences in varieties, flavor is much more influenced by ripening season (later is better), climate (sun is good), and cultural practices (thin well and pick riper for more flavor). Proper handling after picking also is important to preserve fruit quality. The extensive red color of many modern varieties makes it more difficult to determine when they are ready to pick, as the traditional changes in the background color are less obvious.

Ripening Date

Peaches have a relatively short shelf life, so growers must plant a sequence of varieties in order to have ripening fruit season long. Peach varieties are available to ripen in Byron, Georgia, from early May until September. Standard varieties for comparison are Redhaven, which ripens at Byron in mid-June, and Elberta, which ripens mid-July. At the season's extremes, varieties have more weaknesses than mid-season peaches. Early season



fruit tend to have low yields and small size with low fruit firmness and quality. Very late fruit tend to crack, drop from the tree, and have dry flesh. Very early or late varieties can be profitable despite their drawbacks if demand is high, or they may be at a profound disadvantage when marketed against mid-season fruit from other regions. Contrary to popular belief, bloom date and ripe date are not necessarily related, although breeders have gone to lower chilling varieties in order to get larger size in very early varieties. For a given variety, bloom date will be correlated with ripe date, given comparable weather from bloom to fruit maturity.

Ripening dates may vary from year to year due to weather factors. Ripening may be delayed due to later bloom, young trees, heavy crop set, late thinning, cool temperatures during the season,

and other factors. The sequence of ripening may reverse some years, particularly when bloom occurs earlier or later than normal. For instance, in a low-chill year, a later-ripening but low-chill variety may bloom and ripen early, whereas an early-ripening but high-chill variety will have delayed bloom, which may cause the fruit to ripen after the other variety.

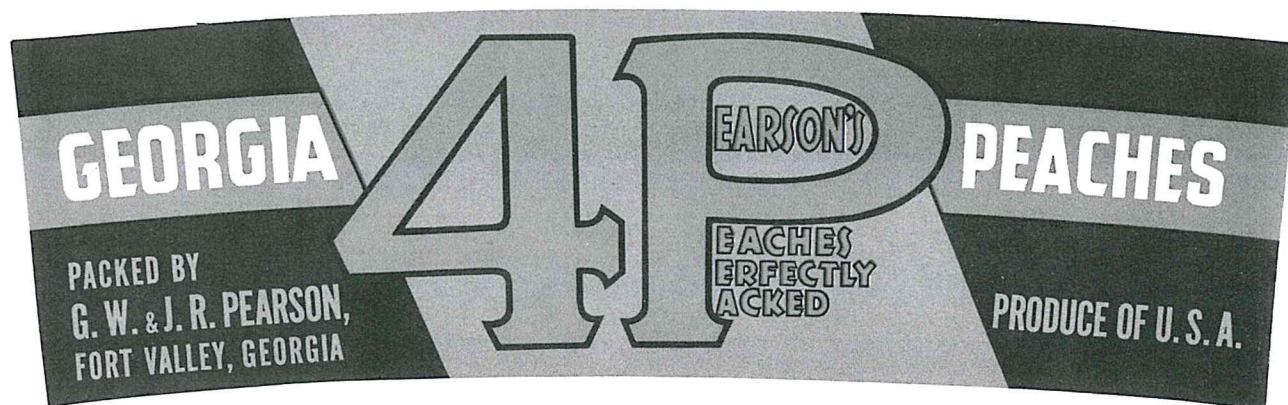
Nectarines

Nectarines and peaches are horticulturally similar. Comments on peaches are relevant to nectarines. However, fewer adapted nectarine varieties are available to southeastern growers. It is difficult and expensive to produce nectarines in the Southeast that are as large and attractive as those grown in California. Disease problems are worse and fruit finish is easily marred by insects and our humid climate.

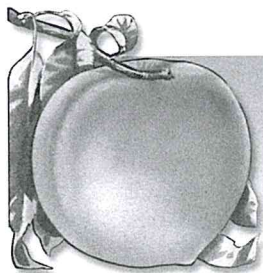


TABLE 4-5-1. Characteristics of low-chill and medium-high chill peach varieties commonly grown in the Southeast. White-fleshed varieties in *italics*; nectarines in **bold. Pit is Freestone, Semi-free, or Clingstone; varietal susceptibility to bacterial spot is rated as Resistant (R), Moderately (MR), Susceptible (S).**

Variety	Pit	Ripe(+/- Elberta)	Chill Hours	Bacterial Spot Rating	Comments
<i>Low-Chill</i>					
Flordadawn	cling	-60	300	MR	
Flordacrest	semi	-50	425	MS	
Flordaking	cling	-48	400	MR	large, pit splits
<i>White Robin</i>	semi	-48	500	MR	
Gulfprince	cling	-41	400	R	non-melting
<i>Medium-high Chill</i>					
<i>Queencrest</i>	cling	-62	650	S	California standard
<i>Camden</i>	cling	-58	750	S	small, split pits
<i>Starlite</i>	cling	-54	650	S	local use
Regal	semi	-54	700	HS	local use
Empress	cling	-52	650	S	similar to Springcrest
Springprince	cling	-50	650	MS	non-melting
Sunbrite	cling	-49	750	S	
Goldprince	cling	-47	650	MR	low vigor
Junegold	cling	-45	650	MR	large, pit splits badly
<i>Scarletpearl</i>	semi	-45	750	MS	local use
Rubyprince	cling	-43	850	MR	
Surecrop	semi	-43	950	R	
Summerprince	semi	-42	850	MR	small size
Garnet Beauty	semi	-38	850	MR	
Juneprince	semi	-38	600	MR	
<i>Southern Pearl</i>	semi	-38	650	MR	large size
Sureprince	semi	-35	950	MR	medium size
Coronet	semi	-34	700	S	
GaLa	semi	-34	700	S	
Durbin	semi	-34	850	MR	green ground color
Karla Rose	semi	-28	650	HS	cracks, good taste
Flavorcrest	free	-28	750	HS	
Redhaven	semi	-28	950	MR	northern standard
Bellaire	free	-25	750	R	
Juneprincess	free	-24	850	MR	
Roseprincess	free	-24	850	MS	tart
Harvester	free	-23	750	MR	
Topaz	free	-18	700	MR	light crops
Cary Mac	free	-17	750	MR	light crops
Fireprince	free	-17	850	MR	
Blazeprince	free	-17	750	R	dark red
Winblo	free	-17	850	MR	
La Feliciana	free	-14	600	MR	local use

TABLE 4-5-1. *continued*

Variety	Pit	Ripe(+/- Elberta)	Chill Hours	Bacterial Spot Rating	Comments
Redglobe	free	-13	850	MR	
<i>White Lady</i>	free	-12	850	HS	very firm, low-acid
Bounty	free	-12	800	MR	large
Loring	free	-12	800	MR	
Majestic	free	-12	750	R	
Redgold	free	-10	850	MS	attractive
Summergold	free	-10	750	MS	
Ruston Red	free	-8	800	R	local use
Contender	free	-7	1050	MR	hardy
Cresthaven	free	-3	950	MR	lacks red
Dixiland	free	-3	750	S	lacks red
Redskin	free	-2	750	MR	dull color
Sunprince	free	-2	800	MR	large, lacks red
Elberta	free	0	850	MR	obsolete
Jefferson	free	+3	850	R	
Summer Lady	free	+5	850	HS	very red
Fay Elberta	free	+6	750	S	lacks red
Monroe	free	+8	750	HS	
O'Henry	free	+13	850	HS	California standard
Flameprince	free	+14	850	MR	
Big Red	free	+22	750	MR	
Parade	free	+30	800	S	drops prematurely
Fairtime	free	+35	750	HS	
Autumnprince	free	+45	850	MS	



4.6 TREE DENSITY, ORCHARD DESIGN, AND TRAINING SYSTEMS

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TREE DENSITY

Maximum sustainable yields of high quality fruit at the lowest cost of production should be the goal of every fruit grower. Yield and quality are functions of the number of trees per acre, training system, and annual production practices such as pruning, fertilization, and pest management.

The productive lifespan of a peach orchard is not long, especially on old peach sites. It behooves the grower to use a tree-training system that returns significant yields early in the life of the orchard. Increasing the number of trees per acre increases yields, up to a point, in young orchards. However, as trees mature, too many trees per acre results in crowding and shading with commensurate declines in yield and fruit quality and increases in pest problems. Ideal tree density will vary, depending on soil type and topography, varieties, rootstocks, training systems, the presence of irrigation, and the grower's management capabilities.

In previous years, it was common to set an orchard "on the square," in which the distance between trees in-a-row equaled the distance between-rows. Oftentimes, the orchard floor was kept free of grasses and weeds by cultivating down the rows and across rows. High fruit quality could be attained because mutual shading was not a problem. Yields were low to moderate because a relatively high percentage of the orchard space was devoted to drive areas and, hence, not covered with fruiting wood.

Planting trees close enough in the row that they almost touch at maturity and leaving an extra eight feet between rows to accommodate equipment movement results in more trees per acre, which

promises potentially higher early yields plus greater yield potential in the mature orchard. With proper management, fruit quality remains high. An orchard floor management system consisting of permanent sod between rows and a continuous vegetation-free strip down tree rows accomplished through the use of herbicides works well with this orchard layout.

In the southeastern United States, a relatively low-density, open-centered vase system has predominated. Among high-density systems, the perpendicular V system appears to be the best to date. In it, trees are set six feet apart in the rows. Between-row spacing should remain the same as in conventional orchards. When orchards are planted on flat ground, rows should be oriented north to south to maximize sunlight within the canopy. Table 4-6-1 shows the number of trees per acre at several different spacings in perpendicular V and conventional plantings. In the perpendicular V system, each tree has only two scaffold limbs—one on each side of the trunk facing the row middles and growing perpendicular to the row. No subscaffolds are allowed to develop. The perpendicular V system can give higher yields early in the life of the orchard. However, at maturity it has no yield advantage over conventional systems.

ORCHARD DESIGN

Optimal orchard design will vary with site. Consider the following points when setting an orchard:

- (1) Leave adequate room at the ends of rows for equipment to turn. At least 30 feet will be needed.

TABLE 4-6-1. Trees per acre at various in-row and between-row spacings.

In-Row	Between-Row	Square Feet Per Tree	Trees Per Acre
6	18	108	403
10	18	180	242
14	18	252	173
18	18	324	134
6	20	120	363
10	20	200	218
14	20	280	156
18	20	360	121
6	22	132	330
10	22	220	198
14	22	308	141
18	22	396	110
6	24	144	302
10	24	240	181
14	24	336	130
18	24	432	101

- (2) Long rows allow for greater efficiency in maintaining the orchard than many short rows. Less time is spent turning at the ends of rows.
- (3) Planting across a slope is preferable to planting up and down. Installation and operation of irrigation systems are simpler. Pesticide application is more precise because it is easier to maintain a uniform ground speed and constant PTO speed. The sod row middles serve as deceleration and diffusion strips for runoff water which lessens the erosion potential. Planting on a true contour is not necessary except where slopes are uneven and steep. True contour planting may result in multiple short rows and the distance between rows may not always be uniform.
- (4) Uniform-shaped fields mean fewer short rows.
- (5) Leaving open spaces in low areas of rows planted across slopes enhances air drainage out of the orchard, which lessens frost and disease pressure and provides an area to turn equipment.

GROWTH HABIT AND FRUITING HABIT

Growth Habit

A peach shoot is made up of a terminal bud, called the apex, and lateral buds along the shoot (Figure 4.6.1). Lateral bud growth is influenced by the terminal bud through action of auxin, a naturally occurring growth regulator. Auxins move downward in shoots from actively growing terminal buds, suppressing lateral bud growth, a phenomenon called apical dominance.

Peaches develop lateral shoots on current season's growth. The degree of apical dominance is shown by growth habit. Orientation or angle of shoots and limbs influences apical dominance (Figure 4.6.2). Apical dominance is strongest in vertical shoots and limbs. In vertical limbs, lateral shoot growth is lacking near the distal end of the shoot; shoot growth near the base of the stem is present but sparse. Orientation at a 45° angle moderates apical dominance, reduces vigor of growth near the apex, and increases both lateral shoot number and length along the limb further from the apex. On horizontal or flat limbs, apical dominance is lost. Without apical dominance to suppress their growth, lateral buds on the upper side of flat limbs

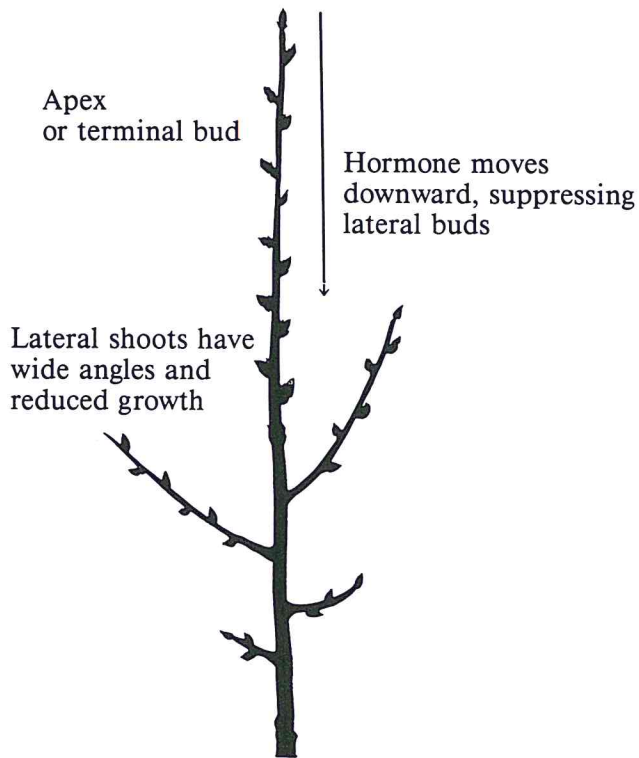


FIGURE 4.6.1. Growth is influenced by apical dominance in which the growing apex or terminal bud produces a hormone which moves downward toward the earth's center. This influences the number and length of lateral shoots as well as the angle at which they develop.

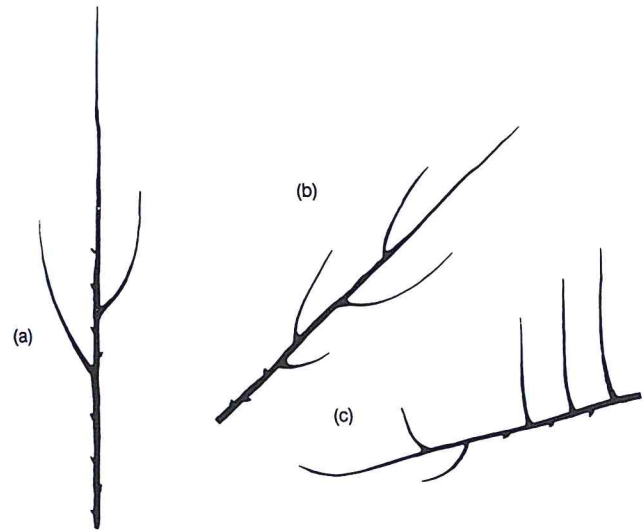


FIGURE 4.6.2. Limb orientation influences apical dominance. On vertical limbs (a), shoot growth near apex is most vigorous with sparse lateral shoots away from apex. On limbs at 45° to 60° (b), vigor of shoots near apex is reduced while number and length of lateral shoots farther away from apex are increased. On horizontal or below horizontal limbs (c), apical dominance is lost and watersprouts develop.

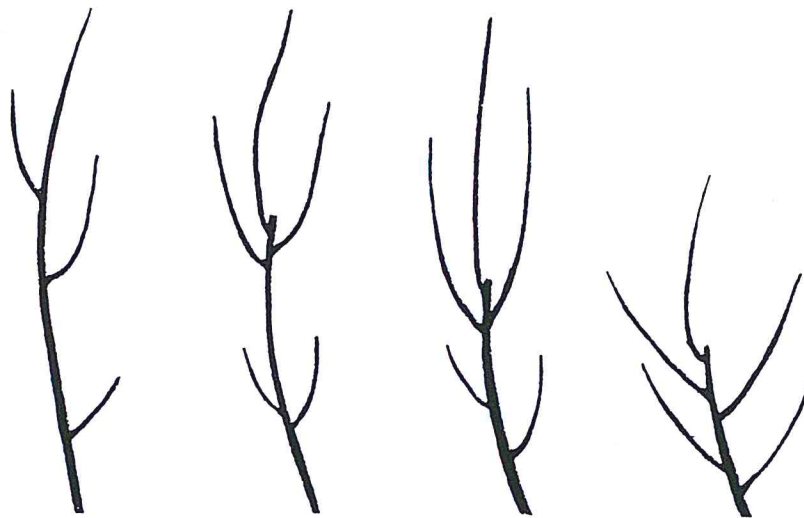


FIGURE 4.6.3. On unpruned limbs (left), apical dominance is intact. Pruning removes apical dominance, stimulating lateral shoot growth near the cut. The more severe the pruning (left to right), the greater the resulting regrowth.

develop into watersprouts. Thus, limb orientation at 45° aids in managing vigor and reducing watersprouts.

Fruiting Habit

Light is critical for fruit wood and flower bud development. Under shaded conditions, flower bud formation is reduced, and, under extreme conditions, fruit wood will weaken and die back. With time, fruiting wood will move up and out from the tree center due to shading.

Peaches are produced on one-year-old wood from flower buds formed the previous growing season. New growth is required annually for cropping. Flower bud initiation begins in mid-summer and extends for several weeks. If vigorous shoot growth occurs after flower bud initiation, there is potential for reduced flower bud numbers. The total number of flower buds per shoot increases as shoot length increases, to around 25 inches. Above 25 inches, flower bud numbers typically decline, often as a result of excess vegetative vigor from too much nitrogen or heading cuts. In cases of excessive vigor, reduced flower bud numbers result from blind nodes, inhibition of flower initiation, and excessive lateral shoot development.

BASIC PRUNING CONCEPTS

Effects of Pruning

Pruning reduces tree growth. That is, the total new growth on an unpruned tree will exceed that of a pruned tree. Pruning allows you to determine where new growth will occur and to invigorate shoots in the vicinity of the pruning cut.

Pruning stimulates regrowth close to the pruning cut. Heading back a shoot removes the terminal bud and eliminates apical dominance in that shoot, thus invigorating growth of lateral buds (Figure 4.6.3). Regrowth occurs closest to the cut on vertical limbs. Regrowth on limbs at 45° to 60° angles develops farther away from the cut. Pruning horizontal limbs too hard aggravates watersprout problems. Heavy pruning removes leaf area and promotes excessive, localized regrowth at the expense of total root growth and tree growth. Early in the tree's life, excessive pruning decreases tree size and root growth com-

pared to light pruning. Trunk diameter and early yields are reduced by heavy pruning. Vigorous shoot growth brought on by heavy pruning inhibits flower bud formation. Reduction of early yields will vary with pruning severity and time of pruning. Light pruning, as practiced in proper summer training techniques, appears to have a minimal effect on young tree growth.

Types of Cuts

There are two basic types of pruning cuts: heading and thinning (Figure 4.6.4). Heading cuts remove the terminal portion of shoots or limbs, leaving a stub, thus stimulating regrowth near the cut. Heading cuts should be used to induce branching at specific points, as in establishing scaffolds and lateral shoot growth at specific locations. However, heading is extremely invigorating and should be used with care.

Thinning cuts remove entire shoots or limbs to their points of origin from a main branch or limb. With thinning cuts, some terminal shoots are left, apical dominance remains, and the stimulation is more evenly distributed among remaining shoots. Thinning cuts are useful to shorten limbs, improve light penetration, and direct growth of limbs.

One misused type of thinning cut is the "bench cut," which prunes an upright limb to a horizontal or flat limb (Figure 4.6.5). Watersprouts develop in the area of bench cuts, especially following large cuts, owing to the absence of apical dominance on the flat limb. Bench cut areas are weak and the flat limb is apt to break at the cut. Benched limbs are also subject to sunburn, winter injury, and infestations of lesser peachtree borer. More correctly, maintain some apical dominance by thinning to limbs at angles of about 45°. If limbs are trained flat, growth can be trained back toward the tree center from flat areas to "absorb" vigor and reduce sunburn. Make pruning cuts when limbs are small, particularly during summer training. Scaffolds should be trained as close as possible to a 45° angle to minimize need for severe bench cuts later.

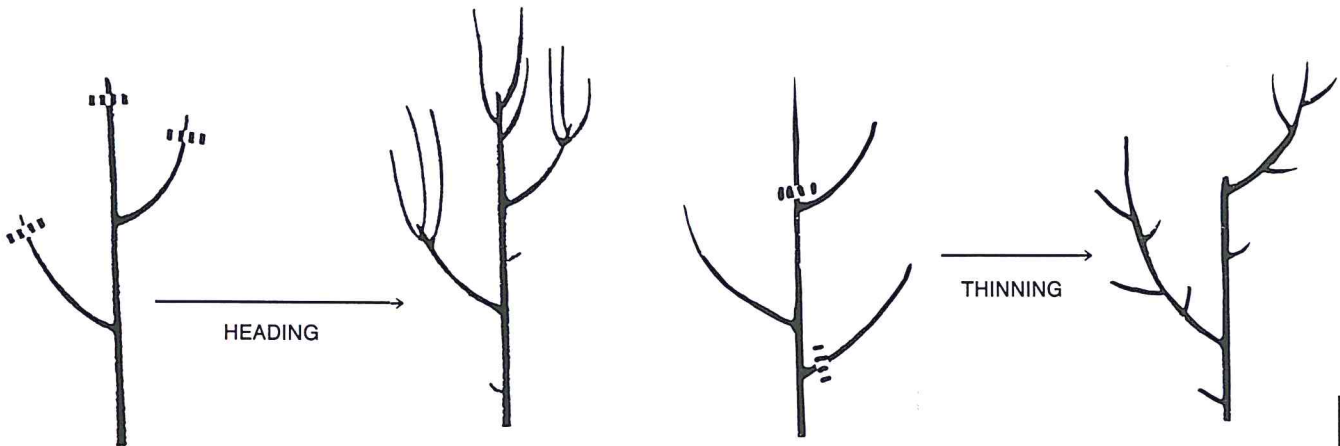


FIGURE 4.6.4. Heading (left) removes a portion of the shoot or limb, stimulating branching below the cut. Heading is most useful for stimulating branching at specific locations when training young trees. Thinning (right) removes an entire shoot or limb to its point of origin or to a side limb. Thinning is the least invigorating type of cut with the least effect on reducing fruit production. Thinning cuts are most useful for promoting fruit production and for maintenance pruning.

4

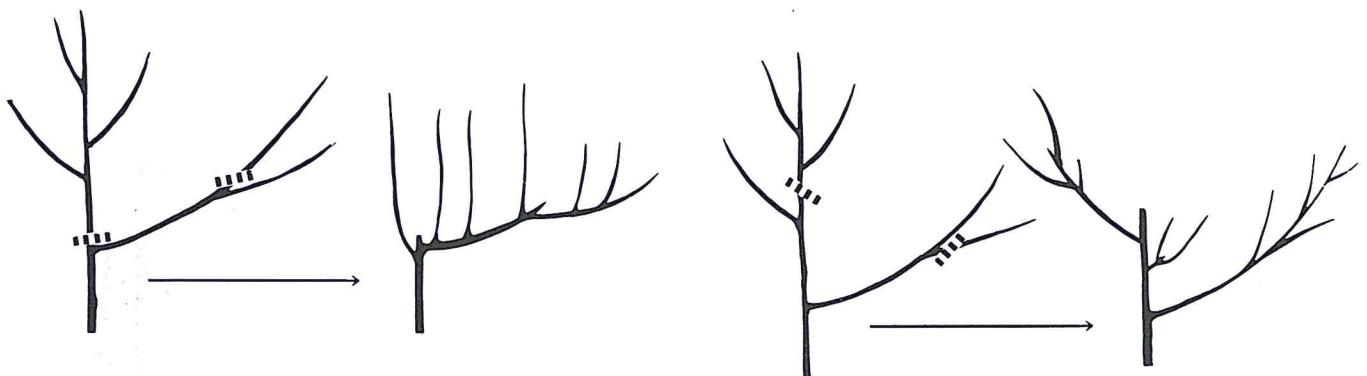


FIGURE 4.6.5. Bench cut (left) is formed by pruning a vigorous, upright limb to a more horizontal limb. Due to loss of apical dominance in the horizontal limb, vigorous water sprouts develop at the "bench." Correct method is to thin to limbs that are more similar in angle (right) to maintain some apical dominance. Scaffolds should be trained to a 45° angle in early years to minimize need for severe bench cuts.

TRAINING AND PRUNING IN PRACTICE

The goal of tree training is to promote favorable growth patterns. Training involves spreading or tying up limbs, staking, and making as-needed cuts (pruning) to direct the growth in certain areas. Training is used to bring trees into production earlier, to develop a strong structural framework that will support heavy crop loads without breaking, to promote good sunlight penetration throughout the canopy, and to make the trees easier to manage. Primary tree training should be accomplished during the first three or four years of a tree's life.

Pruning involves making cuts to:

- (1) eliminate unproductive or marginally productive wood;
- (2) encourage the growth of new shoots for future production;
- (3) remove insect-infested and disease-infected wood;
- (4) promote light penetration throughout the canopy to maintain fruitfulness of the lower and interior shoots, maintain fruit quality, lessen pest pressure (good light penetration is associated with air movement and spray penetration throughout the canopy); and
- (5) maintain the tree within desirable size limits.

Pruning should be conducted annually throughout the life of the tree.

OPEN CENTER SYSTEM

The open center or vase system is most commonly used for training peach trees. Open center trees are relatively low with all or most of the crop reachable without the use of ladders. Fruit quality is fairly uniform throughout the canopy and the system is easy to understand so workers can be taught to use it with minimal difficulty. The open center system is a modification of the peach's natural, rounded bush shape. It generally consists of three or four scaffold limbs well placed both vertically and around the trunk. Several different methods for training peach trees to the open center system exist, beginning with the newly set tree and continuing through the training years.

Developing the Open Center Training System for Peach Trees

The ideal open center tree shape involves:

- (1) 3 or 4 scaffold limbs uniformly spaced around the trunk, arising within a 6-inch vertical distance from each other, with the lowest branch being 18 to 24 inches above-ground and growing outward from the trunk at a 45° angle;
- (2) subscaffolds on either side of each scaffold limb
 - a) no subscaffolds within 36 to 48 inches of the base of the scaffold limb;
 - b) select subscaffolds on alternate sides of the scaffold limb and spaced 24 to 48 inches apart;
 - c) growing outward from the scaffold limb at a slightly upward angle;
 - d) never extending further out of the canopy than the scaffold limb; and
- (3) maintaining the center of the tree largely free of watersprouts or vigorous shoots that grow back toward the center of the tree.

Depending on tree growth rate, the scaffold limbs should be selected within the first year of tree growth. Subscaffolds will be selected and developed over the next two to three years.

Annual pruning includes:

- (1) removal of dead, diseased, and insect-infested wood;
- (2) removal of watersprouts, vigorous shoots growing in toward the center of the tree, and removal of hangers (shoots growing on the undersides of scaffolds and subscaffolds);
- (3) removal of wood that fruited the previous year; and
- (4) thinning out new wood for current year's crop and to promote the development of new shoots for the following year's crop.

At Planting

Head trees back immediately after planting to establish the height of the primary scaffolds. Scaffold limbs usually develop within eight inches of the heading cut. Therefore, the tree should not be headed over eight inches above the desired height for the first scaffold limb. Although the scaffold limbs should be close to the ground at the point where they originate on the trunk,

adequate room should be left for weed control next to the trunk and to apply trunk borer sprays. Small trees (3/16 to 3/8 inch in diameter) usually have few laterals on their trunks and those that may be present are usually weak. Remove them completely. Larger trees (1/2 inch diameter or more) usually have pencil-size branches along their trunks. Remove those that are too low and that have narrow crotch angles where they arise from the trunk. Retain laterals that are in a desirable location for permanent scaffolds unless the terminal of the lateral is broken or dried up. Such laterals should be cut back to within 1/4 inch of the trunk. The bud at the base of the lateral should grow and give rise to a new scaffold candidate.

Variations of how to start an open center tree include:

- (1) Head the tree below the height desired for any scaffolds and remove all laterals below this point. A new shoot will be trained up from below the heading cut and all the scaffolds will be developed from laterals arising from the new shoot.
- (2) Head the tree six to eight inches above the height desired for the scaffold limbs. Cut all laterals in the desired height range back to within 1/4 inch of the trunk. New scaffold candidates will arise from buds at the base of these stubs. Entirely remove laterals that are below the height desired for scaffolds.
- (3) The “side leader” method entails heading the trunk just above a good lateral having a wide crotch angle and arising at the desired height for scaffold branches. This lateral should be pointed into the prevailing wind. Entirely remove all remaining laterals. Head the remaining lateral back to within 10 to 12 inches of its base. All scaffold limbs will arise from buds on the sides and lower part of this lateral.

First Summer

Shoots within a few inches of the heading cut tend to be upright in growth habit and very vigorous. They will have narrow crotch angles. Shoots arising lower on the trunk tend to have wider crotch angles and make better scaffold limb candidates. Early in the growing season, pinch the tips out of the vigorous, undesirable shoots to temporarily stop their elongation. If they have

grown a lot before summer training is done, these shoots may need to be broken in half to stop their growth (Figure 4.6.6).

Select three or four shoots to be developed into scaffold limbs. They should have wide crotch angles growing out at about a 45° degree angle from the trunk. These shoots should not be tipped, rather they should be allowed to grow throughout the summer. Oriental fruit moths can destroy the growing point on a shoot and thus lessen the desirability of the shoot as a scaffold limb. If the terminal growing point is destroyed, a lateral bud will break and give rise to a shoot that will take over as the dominant growing point, sometimes destroying the symmetry of the limb.

First-Year Dormant Training

Complete selection of scaffold limbs if necessary. Select branches that are uniformly distributed around the trunk and that arise within six inches of each other vertically. Avoid upright limbs having a narrow crotch angle, as these limbs are weakly attached to the trunk. Their upright growth habit makes them too vigorous, and when a limb having a narrow crotch angle splits off the trunk (and it will split off), it tears down the trunk, doing tremendous damage. Limbs that have very wide crotch angles and that are almost flat in their growth habit give rise to many watersprouts. If necessary, flat scaffolds can be tied up early in their life to develop a more desirable growth habit. As previously mentioned, scaffold limbs growing at about a 45° angle are most desirable.

As the scaffold limb grows, develop subscaffolds on each side starting about three feet from the crotch (Figure 4.6.7). If necessary, “thinning cuts” can be used to force subscaffold development. Develop subscaffolds on both sides of the scaffold branch to give balance to the limb. Avoid leaving too much structural wood, as light levels may get too low for development of fruiting wood. Like the scaffold limbs, subscaffolds should also grow outward and upward at a 45° angle. Avoid making bench cuts on the scaffold limbs to force subscaffold development.

If the tree has grown well and scaffold limbs are well developed, the center of the tree above the highest scaffold can be opened up. Retain some

laterals along scaffold limbs to lessen chances for sunburn and for early production. Remove shoots arising from the trunk below the scaffold branches.

Second Year – Summer

Continue scaffold and subscaffold limb development. Summer pruning and tying up or down of scaffolds to approximate a 45° angle may be necessary. Remove watersprouts arising along scaffold branches.

Second Year – Dormant Pruning

Continue subscaffold selection and development (Figure 4.6.8). These limbs should be well positioned around the tree to give a full canopy, but not so full that shading inhibits development of fruiting wood. Remove watersprouts and hangers (fruiting wood that grows on the underside of limbs) and thin out fruiting wood along scaffolds and subscaffolds.

Third and Fourth Year – Summer Pruning

Remove watersprouts and other limbs with undesirable angles. Retain weaker shoots for fruit bud development and to protect limbs against sunburn.

Third and Fourth Year – Dormant Pruning

Continue to develop subscaffolds if necessary. Develop subscaffolds at approximately two- to four-foot distances. At the end of the third to fourth year, a tree should have three to four primary scaffolds with six to eight secondary scaffolds four to six feet above-ground. At a seven- to 10-foot height, additional limbs fill the tree periphery. If excessive structural limbs develop, remove them before shading becomes a problem.

Remove watersprouts, excessively vigorous shoots, hangers, and shoots growing back across the center of the tree. Prune fruiting wood back toward the scaffolds and subscaffolds using thinning cuts to encourage annual shoot growth close to these limbs and to increase light exposure for the remaining wood (Figure 4.6.9).

Maintenance of Mature Trees

Detailed pruning throughout the tree is critical in maintaining high yields of quality fruit. Fruiting shoots must be thinned out and spaced to adjust

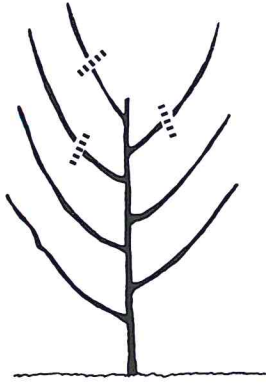
the crop load and promote the development of new shoot growth for the following year's crop (Figure 4.6.10). The amount and spacing of fruiting wood left in trees will depend on variety and tree height and vigor. Fruiting branches should not get too old or far away from the scaffold or subscaffold limbs. To prevent this, prune fruiting branches back to lateral shoots near the scaffolds to encourage new growth close to scaffolds. Remove hangers; they produce small fruit and shade out more desirable fruiting wood.

As trees reach the desired height and fill their in-row and between-row spacing, prune to maintain tree size. This is most easily accomplished by annual pruning, consisting of a summer and a dormant pruning. Ultimate tree size (height and width) must be determined by the grower. At a minimum, trees should be tall enough so that the top of the tree is almost out of reach by pickers. Higher yields can be attained by allowing trees to grow taller, although use of ladder harvesting will be necessary for part of the crop.

Maintenance pruning should largely involve thinning cuts. Vigorous, upright growth (often called watersprouts) that develops inside the tree and at the ends of scaffolds and subscaffolds (crow's feet) should be completely removed (thinning cut) to prevent shading of productive fruiting wood. Leave only one growing point at the end of each structural limb. Otherwise, crow's feet shade out fruit wood. Severe pruning, particularly misuse of heading cuts, will unnecessarily invigorate the tree, resulting in shading in the tree center and reduced fruit color (Table 4-6-2). Nitrogen fertilization should be adjusted, along with pruning, to the tree's needs based on fruit quality, shoot growth, and foliar analysis.

Pruning bearing trees during the growing season (summer pruning) can greatly complement the overall pruning program, but should never be considered as a substitute for dormant pruning. The development of excessively vigorous, upright growth is apparent in some trees by mid-season. Remove vigorous upright growth several weeks before harvest to increase light penetration within the tree. Light has a positive effect on development of red color of fruit. Moderate removal of vigorous

TOPPED CENTER



DELAYED HEADING

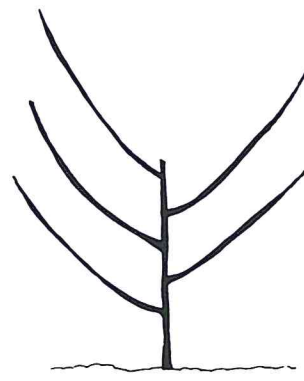
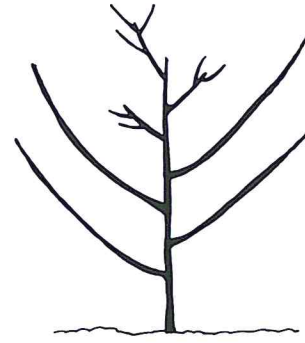
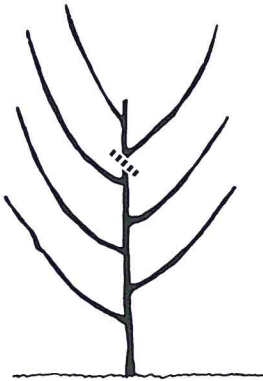


FIGURE 4.6.6. Methods to train first-summer trees. Topped center (top) involves cutting the top two to three shoots in half early to mid-season to form a "bush" in the tree center. Delayed heading (bottom) involves complete removal of the top two to three shoots below the initial heading cut. Both methods direct growth into more desirable scaffolds. Topped center method is preferred because "bush" acts to force scaffold out and up, maintaining more ideal angles.

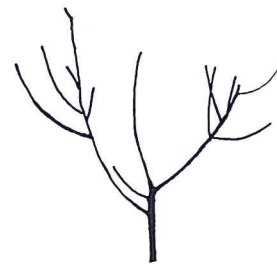
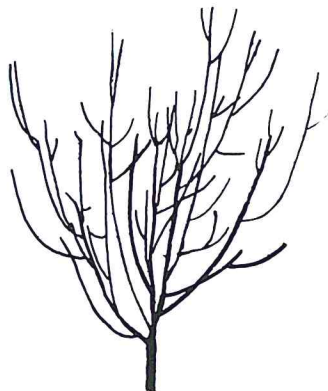


FIGURE 4.6.7. One-year old tree before (left) and after (right) first-year dormant pruning. Select three to four well-spaced primary scaffolds, ideally spaced several inches apart vertically. Prune primary scaffolds to laterals (which form secondaries) at around three feet from the crotch. Thin out vigorous upright shoots in center but leave some weaker laterals.

TABLE 4-6-2. Effect of pruning methods on light penetration and fruit color in Elberta peach trees (Westwood and Gerber 1958).

Pruning Method	Light in Tree (% full sun — Aug.)	Red Blush Color (%)	Undercolor Rating (2 = green to 4 = yellow-amber)
Corrective	60	54	3.6
Thinning out	60	58	3.7
Conventional	55	42	3.3
Severe	35	26	3.2
Corrective pruning: removal of crossing and broken limbs			
Thinning out: moderate pruning using thinning cuts			
Conventional pruning: thinning out shoots plus heading remaining shoots in half			
Severe pruning: 50%-75% shoots removed plus severe heading of remaining shoots			

growth also helps maintain health of fruiting wood. However, excessive summer pruning before harvest can invigorate the tree, delay maturity, and reduce fruit color and size. Vigorous regrowth after heavy, late-summer pruning (July - August) reduces flower bud set. Summer pruning should consist of thinning cuts made within the tree canopy that open up areas to light penetration. Removal of some, but not all, vigorous watersprouts within the tree center will keep fruiting wood healthy but not subject the tree to sunburn.

Avoid or minimize heading main scaffolds and subscaffolds until after they have attained their final size. Heading a limb lessens the basal portion of the limb's ability to bend. Heading cuts can also create a weak area at the site of the cut. By not heading, limbs remain more flexible and will bend with increasing loads rather than breaking. If a subscaffold branch threatens to outgrow the main scaffold, it is often best to remove it entirely rather than head it back. Once the scaffold fills its allotted space, if it bends too much, it can be headed to maintain the proper growing angle (45°). Likewise, if the scaffold outgrows its space, it can be headed to re-establish the proper spacing.

Modifications

Several modifications to the open center system may be worthy of consideration. A multiple scaffold vase system may have promise. It involves developing eight to 10 scaffold limbs spaced around the trunk and arising within about 12 inches

vertically. These scaffolds are not tipped and no subscaffolds are allowed to develop. Fruiting is restricted to shoots that develop directly off the upper part of the scaffold (as opposed to the sides and bottom of the limb). During dormant pruning, shoots that fruited the previous growing season are removed. Vegetative shoots that did not fruit the previous growing season are retained for fruiting. With this system, the loss of one or two scaffolds will have relatively little effect on yields.

The “perpendicular V” system was briefly described in the section on tree density. This is a free standing, high-density system with trees planted six to eight feet apart in the row and with rows spaced at the normal distance apart. Ideally, rows should be oriented in a north-south direction to reduce mutual shading from adjacent trees. Yields early in the life of a perpendicular V orchard will be higher than with conventional systems. At maturity, no yield difference should be expected between trees on the perpendicular V system as compared to the conventional system unless wide tree spacing is being used.

With the perpendicular V system, one scaffold limb is developed on each side of the trunk facing the drive area between rows. The scaffold limbs may be selected and developed as previously discussed, except there will only be two scaffolds, one on each side of the trunk adjacent to the drive areas. Attention should be paid to selecting limbs having wide crotch angles to assure that they are firmly



FIGURE 4.6.8. Two-year old tree before (left) and after (right) the second-year dormant pruning. Select secondary scaffolds at two to three feet from the crotch. Thin out low and horizontal shoots and excessively vigorous shoots growing toward the center. Maintain scaffolds at a 45° angle, minimizing the use of severe bench cuts.



FIGURE 4.6.9. Four-year old tree before (left) and after (right) pruning in the dormant season. Fruiting wood is thinned out to reduce the crop load. Health of fruiting wood is maintained throughout the tree by adequate light penetration. Thin branches back toward scaffolds to encourage new shoot growth close to scaffolds. Light summer pruning may be useful to maintain light penetration in tree centers, maintaining health of fruiting wood throughout the tree.

attached to the trunk. The ideal angle for scaffold limb growth is 45° from the vertical orientation. More vertically oriented limbs tend to be too vigorous and flatter-growing limbs have a lot of watersprout development on the upper side.

Because perpendicular V trees have only two scaffolds, limb breakage is very detrimental to yield. By not heading the scaffolds until they have attained their final length, the scaffolds will be more apt to bend instead of break with the weight of the crop. Once the scaffolds have reached their desired length, heading is typically needed. With unheaded scaffold limbs, problems are sometimes encountered when winds turn one of the scaffolds back over the center of the tree. Watersprouts should be removed during the summer. Annually renew fruiting wood to keep the crop on shoots arising directly from the scaffold branches. No subscaffolds should be developed on perpendicular V trees.

SPECIAL CONSIDERATIONS

Mechanical Topping

Mechanical toppers may be used to maintain tree height. Mechanical toppers prune in an efficient, but non-selective fashion. Topping should be complemented by detailed hand pruning. Topping makes non-selective heading cuts. Vigorous growth occurs immediately below cuts, forming "crow's feet." Follow-up, detailed hand pruning is necessary to clean up crow's feet or shading will occur.

Toppers are often used in the summer to increase light penetration in the tree center. However, if done too early in the season, vigorous regrowth from topping can actually increase shading problems.

Topping does not reduce over-all costs and, in some cases, may actually increase them.

Methods to Support Crop Load

Many varieties, when grown using good cultural practices, are capable of sizing more fruit than the scaffold limbs can physically support. This is especially common when young trees are heavily cropped. To take advantage of early cropping and heavy yields, many growers employ various methods such as tying, strapping, or banding scaffolds to support the crop.

As the weight of fruit increases and one, some, or all of the scaffolds begin to droop, the twine distributes the weight of the fruit load throughout the tree. If all scaffolds are heavily burdened with fruit, the circle formed by the twine bears the weight and keeps scaffold breakage to a minimum. Avoid encircling or wrapping entirely around scaffolds as girdling can occur. When circling the tree, be sure the major fruiting area is within the circle. Always leave 15 to 18 inches of slack when tying the ends together to allow for limited limb bending. If the string is tied too tight, it may break under the weight of a fruit load.

Tying, if needed, should begin as the tree develops its first sizable crop (third or fourth year), and continue according to the needs of mature bearing trees. Tying should be done before harvest time when limbs begin to spread. Less expensive, short-lived materials can be used on young trees, whereas long-lasting materials are more practical once trees have reached maximum size. An alternative is to leave enough slack to adjust the tying as the tree increases in size.

Pruning Time and Method

In the Southeast, research has shown that tree mortality is increased by pruning in late fall through early winter, October through January (Figure 4.6.11). If winter pruning is practiced, late winter is preferred over early winter. Prune the oldest and/or worst orchards first and prune the youngest orchards last. A combination of summer and dormant pruning may reduce the need to prune during undesirable periods. In northeastern areas, recommendations for Cytospora canker (Valsa) control (particularly in young blocks) include delaying pruning until growth begins in spring, after bloom but before the shuck-split spray. However, research in West Virginia found that pruning method affected Cytospora infection, but found no difference between trees pruned in winter, spring, or summer. Pruning cuts that left a raised collar resulted in less Cytospora infection compared to flush cuts.



FIGURE 4.6.10. Mature tree before (left) and after (right) dormant pruning. Fruiting wood is thinned out to adjust the crop load depending on variety. Branches are thinned back toward scaffolds to encourage new shoot growth close to scaffolds. Vigorous upright shoots are removed from the center but some weaker shoots are left to provide sunburn protection. Some annual summer pruning may be necessary to maintain light penetration in tree to keep interior wood healthy.

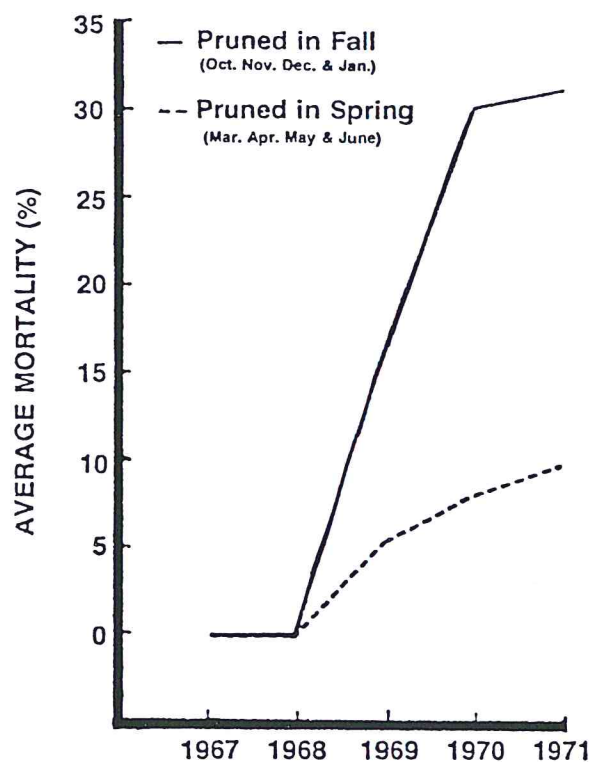
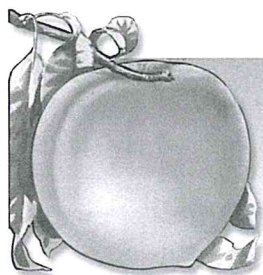


FIGURE 4.6.11. Effect of pruning time on mortality of Loring peach trees in a replant site at Fort Valley, Georgia (Daniell 1973).

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4.7 SELECTING AND HANDLING YOUNG TREES

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June-budded trees are the most commonly planted peach trees in the Southeast. Nurseries produce these trees by fall seeding of desirable under-stock seed. Scions are T-budded from late May through mid-June; buds are forced two to three weeks later. Saleable trees are dug in late fall or early winter. Because trees are propagated early in the season, peach growers should place tree orders early to ensure availability. Growers should purchase trees from reputable sources and deal with nurseries that use seed and scion sources annually tested for key viruses. Also seek assurances of true-to-name varieties on recommended rootstocks free of nematodes, insects, and diseases before you decide on a source. Trees should be grown in soil free of nematodes.

The primary rootstocks recommended for use in the Southeast are Guardian, Halford, Lovell, and Nemaguard. Guardian, which has shown to give better survival and growth in a short life site, is becoming increasingly popular. Halford has performed as well as Lovell and is more available than Lovell. Nemaguard is cold sensitive; it is only appropriate in the warmest southeastern production areas. Nemaguard should be planted to control damage from Southern (*Meloidogyne incognita*) or Javanese (*M. javanica*) root-knot nematodes on land new to peaches in areas not subject to frequent damaging winters. For additional information on these rootstocks, refer to the "Nematodes" and "Peach Tree Short Life" chapters.

When the trees arrive from the nursery, open the bundles immediately to prevent heat buildup. Examine the roots thoroughly. If there are knots

or galls on any of the tree roots, report the matter to your nursery and ask your county extension agent to have the galled roots examined by a diagnostician. These abnormalities are probably due to root-knot nematodes or crown gall. If trees with crown gall or root-knot infections are planted, you may experience some initial tree loss and subsequent poor tree growth and performance. In addition, you are infesting your land with two noxious parasites. Root-knot nematodes will be very difficult and expensive to control later. Crown gall cannot be controlled later and the land will be permanently infested.

Root systems of trees arriving from the nursery should be moist. If drying out has occurred, notify the nursery immediately as to the condition of the trees upon arrival. Some compensation may be due should the trees not survive. Soak the root systems in water from 12 to 24 hours in an attempt to revitalize them.

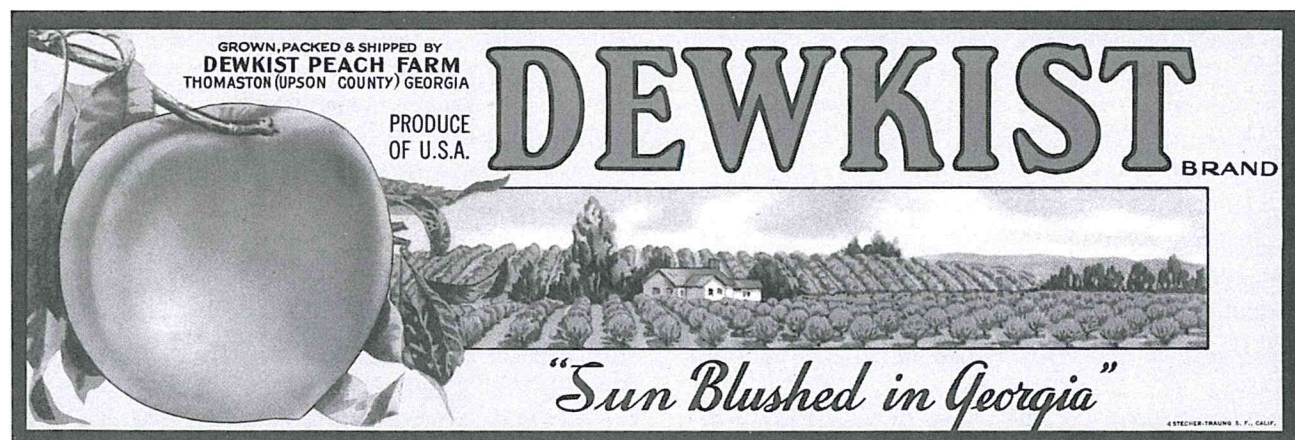
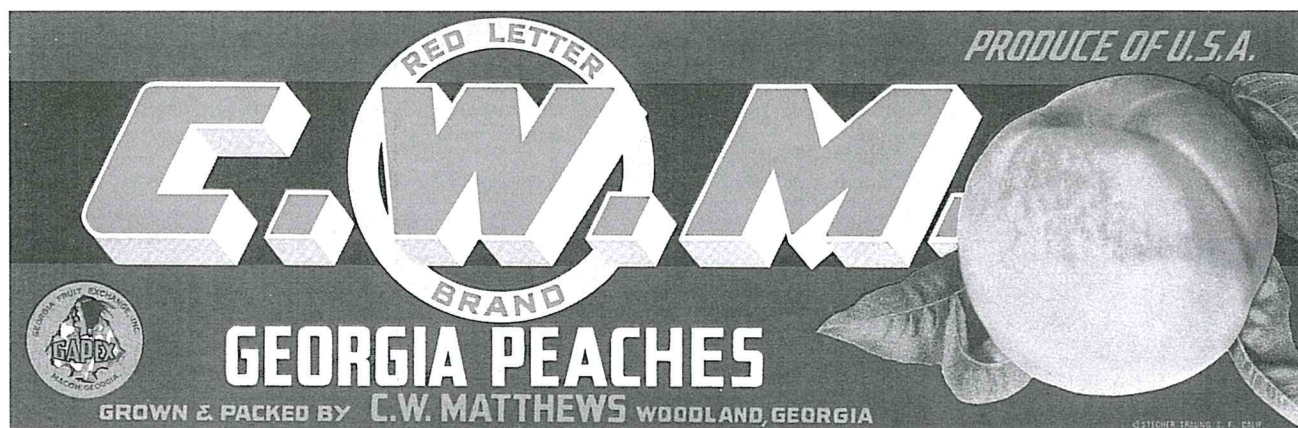
After thoroughly examining the trees, take great care to keep them in good condition until they are planted. It is most important to keep the root system moist and cool at all times. Banking in a moist medium or wrapping in wet sacks is recommended if planting will be done immediately.

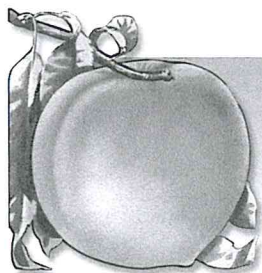
If it is not possible to plant the trees immediately, place them in cold storage at 35° to 40°F. Growers may want to pre-plant dip the trees to control peach leaf curl (see current peach IPM guide) before placing them in storage. Following dipping, repack the trees in nursery shipping containers or place them in bins. If using bins, put two to

four inches of pine bark, green pine shavings, or green pine sawdust in the bottom of the bin. Then pack the bin with bundles of trees in an upright position (only one variety in a bin for ease of locating trees) and fill in around the trees with any of the above-mentioned pine materials. Then, as planting time arrives, trees will be ready to go to the field in the bin.

Where cold storage is not available, the trees should be "heeled in" outdoors. Heeling in means

laying the trees on the side of a trench (roots in the trench) in a sloping position with the tops of the trees pointing toward the southwest to reduce trunk heating from the sun and covering their roots with soil. The soil should be packed tightly around the roots, eliminating air pockets. The "heel yard" should be pre-tested for nematodes before using and fumigated if tests reveal the presence of nematodes. Your county extension agent can assist you with nematode sampling and will make recommendations if fumigation is necessary.





4.8 PLANTING YOUNG TREES

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Peach trees should be planted while fully dormant during the period from early December to mid-March. Because root growth may occur during the relatively mild winters experienced in parts of the Southeast, planting in December may be advisable, provided soil conditions are suitable. However, when trees arrive from the nursery and soil conditions are not ideal for planting, trees should be stored or "heeled in" as described in the "Selecting and Handling Young Trees" chapter. When soil conditions become favorable, plant trees as early as possible so the roots will establish before spring growth begins.

The planting site should be prepared as outlined in the "Site Selection and Preparation" chapter. Planting a tree is a relatively simple task if a few simple guidelines are followed: (1) prune off damaged roots before planting; (2) place roots in their natural position as nearly as possible; (3) plant the tree at the same depth it grew in the nursery; and (4) never mix nitrogen fertilizer in the planting hole or put it on the loose soil immediately after planting. Fertilization should be carried out as described in the "Nutrition" chapter. Three methods are commonly used to plant trees: (1) mechanical tree planter; (2) auger; and (3) furrow. The advantages and disadvantages of each method will be discussed; however, all possibly lead to excessively deep planting. Research shows that the tree's root system must be set no more than two inches deeper than nursery depth if maximum growth and livability are to be obtained.

Correct depth of planting is important in all soil types but critical in heavier soils. Table 4-8-1 gives the results of a planting study that shows the results of shallow planting on tree growth.

The mechanical tree planter offers growers a method to plant large numbers of trees in a short period of time. Experiences in Georgia and South Carolina show that a three-person planting crew can plant an average of 400 to 600 trees per hour under ideal planting conditions. Growers that have used this method of planting feel the transplanter can pay for itself in labor savings if 10,000 or more trees are planted. Tree livability has also been excellent using the mechanical tree planter. Because large numbers of trees can be planted in such a short period of time, growers can plant during brief periods of good winter planting conditions rather than waiting for the drier conditions of spring.

Thorough subsoiling of the orchard site prior to planting the trees is essential to prevent "transplanter syndrome." Transplanter syndrome is best described as a concentration of tree roots in the transplanter furrow that ultimately results in the leaning of trees at right angles to the furrow. If cross-checking with a subsoiler is done to mark where the trees should be planted, the trees should be planted exactly where the transplanter and cross-check intersect. Because the mechanical tree planter is a rapid method of planting trees, some hand follow-up may be necessary to straighten leaning trees or to adjust the depth of planting.

Use of a tractor-mounted 18- to 24-inch auger also provides a very reliable system for digging tree holes prior to planting. One of the more common errors in the use of an auger is to drill the holes too deep. Although this practice does make the subsoil looser, the young trees often sink to an unacceptable depth due to soil settling. Holes should be dug only deep enough to accommodate the tree.

TABLE 4-8-1. Effect of planting depth on leaf size, trunk growth, and anchorage of mechanically planted nectarine trees in Virginia.

Depth to Crown Roots (in)	Year 1: Mean Leaf Area (in ²) in May	Year 2: Trunk Cross Sectional Area Increase (in ²)	% Suffering from Drying Air Pockets Around Roots
2	6.2 a	1.4 a	14 a
4	4.4 b	0.7 c	43 ab
6	4.4 b	0.9 bc	100 c

Adapted from Lyons, C.G. Jr., K.S. Yoder and R.E. Byers. 1982. Growth of mechanically planted nectarines at various depths. Hortscience. 117: 968-969. Means followed by the same letter within a column are not significantly different in Duncan's new multiple range analysis ($P < 0.05$).

Do not use an auger or tree planter on extremely wet clay soils because the auger action tends to seal this area, restricting movement of roots into adjacent soil. This sealing action (glazing) also results in poor internal drainage of soil water. Glazing can be reduced by welding a two-inch long piece of metal to the edge of the auger. This metal protrusion greatly reduces glazing and aids young tree growth.

The furrow method of planting peach trees is of particular value on lighter soils with small trees (18 to 24 inches), but can be used for larger trees. If furrows are cut deeply enough (12 inches) while laying off the rows, little additional digging will be required when planting the trees. Cross-checking with a single shank subsoiler when using the furrow method can be a good way to mark where the trees will go. When trees are to be planted at the intersection of furrows and the subsoil check, the orchard site should be laid off just prior to planting to avoid excessive drying of the soil and to allow for maximum ease of planting in freshly tilled soil.

When planting trees by hand, care should be taken to work the soil around the roots to eliminate air pockets. Good root/soil contact will encourage better tree survival and growth. If soils are dry at planting, watering the trees will further help to get good root/soil contact.

Regardless of the planting method used, trees should not be planted in overly wet soils. Dry soils should also be avoided unless trees will be watered immediately after planting; however, post-plant watering is not always feasible.

Each tree planting method has its own strengths and weaknesses, but, when properly used, each will give satisfactory results. Table 4-8-2 shows that the tree planter, properly used, gives slightly better plant performance both in growth and anchorage over conventional augers, but no growth improvement over a modified auger. Unless a grower has a large number of trees, a planter may not be a justifiable expense. Therefore, the trench method or the modified auger may be the preferred method.

TABLE 4-8-2. Growth and anchorage of 1-year-old Rome apple trees as influenced by planting method in West Virginia.

Tree Planting Method	Total Shoot Growth (in)	Uproot Force (lb)
Tree Planter	170 a	337 a
Conventional 24" Auger	142 b	288 b
Modified 24" Auger	174 a	266 b

Means followed by the same letter within a column are not significantly different in Duncan's new multiple range analysis ($P < 0.05$).