

PEACH TREE PHYSIOLOGY

David W. Lockwood

Department of Plant Sciences & Landscape Systems
University of Tennessee
Knoxville, TN 37996

D. C. Coston

Agricultural Experiment Station
Oklahoma State University
Stillwater, OK 74078

Peach growers strive to produce consistently good yields of high quality fruit. The peach tree's purpose in producing fruit is simply to reproduce, to develop viable seed. Much of fruit culture is skilled manipulation of the tree's reproductive processes to achieve our goals. This section reviews the growth and reproduction of peach trees and their interaction with the environment. This information provides a foundation for the cultural practices detailed in later sections.

The peach (*Prunus persica*), native to China, is a member of the stone fruit family, which also includes cherries, plums, apricots, almonds, and a number of wild species. Cultivars (varieties) in production have been developed primarily through breeding programs that have incorporated desirable characteristics of their native cousins. The peach is adapted to areas with warm growing seasons and is considered to be moderately winter hardy.

FLOWERING

The flower buds of peach develop in leaf axils on current season's growth. These buds will bear the following season's fruit. The terminal bud on a peach shoot is vegetative. Flower buds on peach trees are said to be "simple" or "pure," as they contain only flower tissue, which contrasts with the apple's mixed buds from which both flower and leaf tissues arise. In the peach, one flower comes from each bud.

In winter, examination of a peach shoot about 1-1/2 feet in length reveals several bud arrangements (Figure 1). Near the upper end, single buds (one at a node) of two types predominate. There are single, small, pointed vegetative buds, and the somewhat larger, rounder, more pubescent (hairy) flower buds. In the lower two-thirds of the shoot, many of the nodes have three buds arranged side by side. The two outer flower buds are larger and rounder; the center leaf bud is frequently very inconspicuous, small, and pointed.

In peach culture, vegetative and reproductive processes can be considered competitive. Balancing these processes is necessary in order to achieve consistent, high quality fruit production. The shoot length and buds on current season growth are key indicators of the balance between vigor, nutrition, and tree training that growers must maintain. The need to balance vegetative vigor and fruiting places a premium on growing a moderately vigorous tree with average terminal growth of 15 to 18 inches. Short, weak shoot growth (as on a weak tree) is not productive. Often there is only one bud at each node, typically a flower bud. These weak flower buds may open and perhaps bear fruit, but the weak shoot that bore them will not size fruit and normally makes only weak vegetative growth. The majority of the crop from weak shoots is borne near the tips of branches, and yield is low.

Moderate vigor is the grower's goal. On moderately vigorous shoots, the proportion of paired flower buds (with a vegetative bud between) is high. Individually paired flower buds do not differ from single buds, however, the presence of a leaf bud at each node provides for branching, which in subsequent years may be fruitful.

Extremely vigorous growth also reduces fruitfulness. Under excess vigor conditions, nodes with paired fruit buds frequently break and develop a vegetative shoot without flowering. Relatively few fruit buds will arise on the subsequent rank growth.

Peach flowering is a lengthy, time consuming process that is divided into three steps: (1) initiation, (2) differentiation (development), and (3) anthesis. **Initiation** occurs when meristematic (growing) regions cease producing vegetative tissue and shift to production of reproductive (floral) tissue. Initiation is a biochemical event and certain morphological

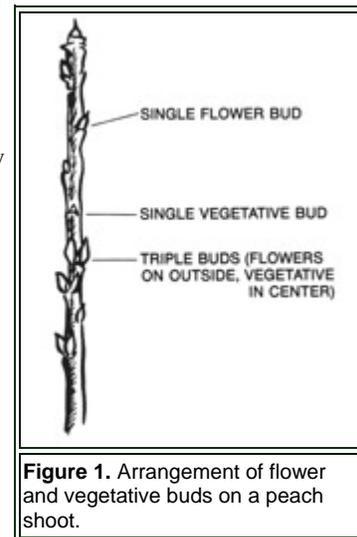


Figure 1. Arrangement of flower and vegetative buds on a peach shoot.

(structural) events follow. This phenomenon can be observed with a microscope after it has happened. Although the process is poorly understood, it is thought to be controlled by naturally occurring plant hormones, including auxins, gibberellins, cytokinins, and abscisic acid. In the Southeast, flower bud initiation in peach trees usually occurs in late June or July.

Flower bud differentiation occurs from the time of bud initiation until the flower opens. In the weeks following initiation, the various floral structures develop. By early fall, these structures are visible through a microscope. In the spring, during the final two or three weeks of development, the reproductive cells, the sperm cell in the pollen grain and the egg cell in the ovary, are formed and are functional when the flower opens.

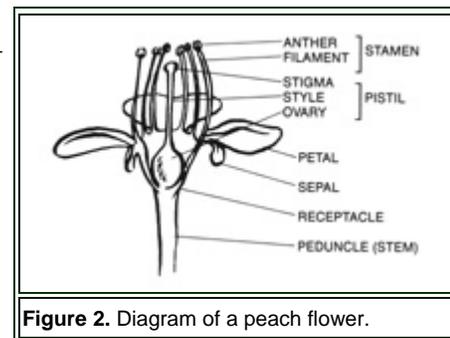
Anthesis, the final phase in flowering, is the opening of the flower.

Flowering is a process that involves many months from initiation to anthesis. In late summer, the buds enter dormancy, a state of inactive growth caused by either internal or external factors. The following spring, growth will not occur until bud dormancy has been broken by exposure to cool temperatures. This is termed the "chilling requirement" and is usually expressed as the number of hours below 45°F necessary to break bud dormancy. Research has demonstrated that different temperatures vary in effectiveness for satisfying chilling requirements. Temperatures in the 40° to 50°F range are most effective, with decreasing effectiveness at temperatures above or below this range. Little effective chilling occurs below 30°F and accumulated chill hours can be partially negated by temperatures in excess of 60°F.

Chilling requirement is of major importance in choosing cultivars. Most peach cultivars require between 600 and 1,000 hours of chilling; cultivars with requirements of 250 hours or less have been developed, which has made peach production in warmer climates feasible.

Peach dormancy has two forms. **Rest**, when the required chilling is being accumulated, is a period when buds will not grow, even if weather conditions are favorable for growth. During the chilling period, key chemical reactions must occur before the plant can once again grow. **Quiescence**, the second type of dormancy, is the period of dormancy the trees enter after their chill requirement has been met. During quiescence, buds break and grow when sufficient warm weather favorable to growth is accumulated. In many southeastern production areas, chilling requirement may be satisfied by late January, but because of cold temperatures, buds do not begin to swell until late February or March. Quiescence is the phase of dormancy between satisfaction of the chilling requirement and the beginning of growth.

The peach flower is termed perigynous (Figure 2). The receptacle is cup-shaped and encloses the ovary. The air space between the receptacle and ovary is thought to provide some insulation during spring frosts. Following bloom, the cup-like receptacle dries and is called the shuck, which splits and falls off as the fruit grows.



FRUITING

Fruiting can be envisioned as commencing with flower initiation and continuing until harvest. Development of a peach fruit from a flower requires pollination. This is the transfer of pollen from the anther to the stigma. Pollen transfer can be accomplished by bees or wind. Peaches (with a few exceptions) are self-fruitful; that is, the pollen from a cultivar will successfully pollinate its own flowers. This action contrasts with many cultivars of apples that are self-unfruitful; that is, pollen from another cultivar is necessary for pollination. Because peaches are self-fruitful, large acreages of a single cultivar may be planted without the need for pollinizer trees.

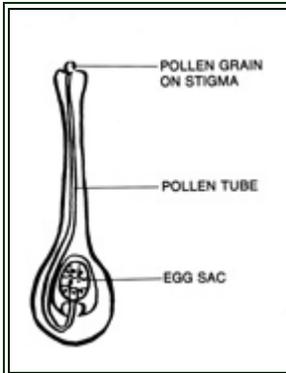


Figure 3. Fertilization of a peach flower.

Once the pollen grain is on the stigma, its wall breaks down and a tube emerges and grows through the style to the ovary (Figure 3). Once there, the end of the pollen tube deteriorates and two sperm cells are released. One sperm cell unites with the egg cell to form the zygote, which will eventually develop into the embryo in the seed. The other unites with two other female cells (polar nuclei) to form the endosperm, which serves as nutritive tissue for the developing embryo. The union of gametes is called fertilization.

Fruit set and growth is a stepwise process that requires pollination, fertilization, and subsequent seed development. Hormonal stimulus from the developing embryo prevents the fruit from dropping and causes the ovary to enlarge. The initial enlargement and development of the fertilized ovary is called fruit set.

Many flowers do not set fruit. Dysfunctional flowers may be missing reproductive structures

because development did not occur, or because of damage from winter cold. Pollination or fertilization may fail even in some healthy flowers. Whatever the cause, many flowers abscise (drop) just after bloom.

The peach is a drupe or stone fruit consisting totally of tissue of ovarian origin (Figure 4). The outer fuzzy skin is the exocarp, the edible flesh is the mesocarp, and the hard pit is the endocarp.

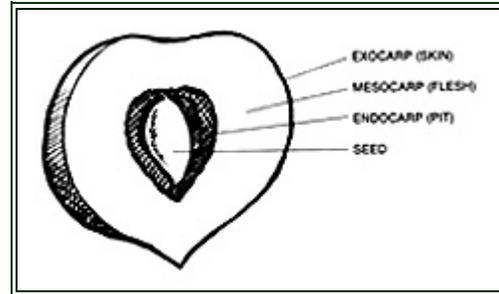


Figure 4. Cross section of a peach fruit.

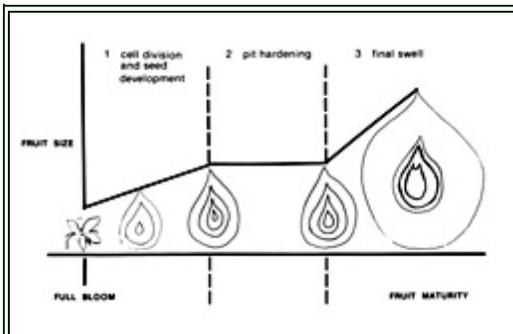


Figure 5. Stages of peach fruit and seed growth.

The size of a peach at harvest is limited by the number of cells present and the size of these cells. In peach, growth of the fruit occurs in three phases (Figure 5). **Phase I, cell division**, occurs in the mesocarp or flesh of the fruit. At the end of this phase, cell division is complete. During this phase, the seed also grows and achieves its maximum length. Phase I lasts approximately 50 days for all cultivars.

Phase II, pit hardening, is predominated by internal changes. It is sometimes termed the lag phase, because the outer dimensions of the fruit change little. However, changes are occurring within. Pits harden and the embryo, which grew little during phase I, develops a primary root, the young shoot, and two leaves (the cotyledons).

In early maturing cultivars, phase II is very short. The normal, double sigmoidal growth curve seen with most peach cultivars is altered. Very early cultivars have a severely abbreviated lag phase.

Phase III, final swell, is a period of rapid fruit growth that is the result of cell enlargement in the flesh of the peach. Phase III lasts about three weeks for most cultivars. As mentioned above, phase I is about 50 days. The major difference in time of maturity among cultivars is the length of phase II, which can vary from a few days to many weeks.

Many growers irrigate during final swell to "blow up" the peach. Indeed this practice helps. However, maintaining adequate moisture during phase I may be more important. The cells formed in phase I are the ones that expand during phase III. Water stress during the early stages of fruit growth can limit cell division and ultimately limit fruit size.

The principles of fruit growth help direct the process of fruit thinning to achieve larger fruit size. Peaches set more fruit than they can grow to commercially desirable size. Envision the tree as having finite resources for fruit growth. Having fewer fruit allows the tree to direct more resources and nutrients to the remaining fruit, which achieve greater size. The earlier excess fruit are removed (thinning), the greater the effect on final size. Judgment on time of thinning, however, must be tempered by considerations of potential frost damage. Peach thinning is discussed in-depth later in the handbook. Once the chance of frost is past and fruit set is known, thinning should proceed as quickly as possible.

PHOTOSYNTHESIS

Photosynthesis has been called the most important process on earth. Energy in the form of sunlight is captured by green plants through photosynthesis and converted to chemical energy. Once captured, energy is available to fuel plant growth and development.

Chlorophyll, a pigment, absorbs radiant energy, primarily in the blue-violet and red portions of the visible light spectrum. We "see" a leaf as green because the green portion of the spectrum is reflected. Chlorophyll is found in tiny structures in the leaf cells known as chloroplasts. It is within chloroplasts that the phenomenon of photosynthesis takes place.

Photosynthesis occurs in the presence of light. Plants combine carbon dioxide and water to produce carbohydrates and oxygen. Carbon dioxide comes from the atmosphere, water from the soil, and the light from the sun. These reactions occur in the chloroplasts and are aided by enzymes, which are special types of proteins. The initial products are simple carbohydrates and oxygen, which is released into the atmosphere.

Photosynthesis actually involves two sets of reactions, commonly called the "light" and the "dark" reactions. During the light reactions, energy from the sun is used to split water molecules (photolysis) to yield hydrogen ions, electrons, and gaseous oxygen, which is released into the air. The hydrogen ions and electrons are used to form high-energy storage compounds. As the names imply, light is essential for the light reactions. In the dark reactions, carbon dioxide from the atmosphere is "fixed" or combined to form carbohydrates. The energy for these reactions comes from the high-energy compounds formed in the light reactions. The dark reactions may occur in both light and dark conditions.

A number of factors affect photosynthesis. Light intensity fuels the process. As light intensity increases, so does photosynthesis until the "light saturation point" is reached, beyond which there is little or no response to increased light levels.

Leaves vary in their photosynthetic potential. A leaf that develops under high light intensity is thicker, with more cells containing chloroplasts and greater potential for photosynthesis than a leaf that develops in the shade. Tree-training techniques strive to expose a maximum of the tree's leaf surface to high light intensities.

Photosynthesis produces simple carbohydrates, which serve as the initial structures for other compounds, as the energy sources for making these compounds, and for maintaining plant processes. Various compounds formed by complex metabolic processes are the building blocks of plant metabolism. The materials manufactured in the leaves are transported to other structures. In the case of peaches, some of this material is transported to the developing fruit and is used in cell division, cell wall formation, carbohydrate (starch and sugar) accumulation, and a range of other phenomena involved in fruit growth. The photosynthetic products are also involved in flower bud initiation and development.

RESPIRATION

Respiration, a continuously occurring process in plant and animal cells, is a set of enzyme-catalyzed reactions in which complex chemicals are broken down to release energy. Respiration generates energy from sugars, starch, fats, proteins, and organic acids. Photosynthesis takes place in the chloroplasts, while respiration takes place primarily in cellular structures called mitochondria. Respiration generates chemical energy for use within the cell. Its end products are carbon dioxide, water, and the energy produced.

In peaches, two types of respiration actually occur. The first type, commonly referred to as **dark respiration**, is that which was described above. Dark respiration takes place both in the light and in the dark, but at relatively low light levels. **Photorespiration**, the second type of respiration, occurs in the light at the same time photosynthesis is in progress. The materials for photorespiration come directly from photosynthesis products, in contrast to dark respiration, which uses stored energy sources. Photorespiration, which is discrete from dark respiration, is estimated to be several times greater in magnitude.

Photorespiration can be inefficient and it is believed to severely limit productivity of many plants, including peaches. In grasses such as corn and sugar cane, photorespiration does not occur or occurs at levels too low to detect. The lack of photorespiration is believed to be the major factor in the high productivity of these crops. Research is in progress to

better understand photorespiration and perhaps suppress it in crops such as peaches. If photorespiration could be restricted without harm to the tree, peach yields could be substantially increased.

When fruit is harvested, respiration does not cease. The harvested fruit is a living tissue. As with most chemical reactions, respiration occurs much faster at higher temperatures. If fruit temperature remains high after harvest, stored carbohydrates (mostly sugars) are rapidly broken down, which results in loss of shelf life and marketability. To prevent rapid decline in the quality of harvested fruit from high rates of respiration, peaches are cooled to remove the heat as quickly as possible. In most southeastern peach operations, this is accomplished by hydrocooling, which cascades cold water over fruit, thus removing field heat and slowing down respiration.