Strawberries have traditionally been a popular fruit for fresh use, freezing, and processing. The per capita consumption of strawberries in the United States is more than 4.5 pounds per year. The 4.2 million residents of Alabama consume nearly 19 million pounds of fresh fruit and other strawberry products annually. The local production of this crop meets only a small percentage of this consumption. In response to demand, strawberry acreage has been steadily increasing throughout the state in recent years. Much of the production has traditionally been in matted row culture with the plantings being maintained for several years. Significant acreage is also being fall-planted as an annual crop using a plasticulture hill system, and the commercial industry is quickly shifting to this technology.

Markets And Marketing Considerations

Assessment of the strawberry market potential of your area and the possible methods of marketing the fruit is a critical first step in the successful management of any strawberry farm. The decision to begin or expand strawberry production must be based on a careful evaluation of potential markets.

Potential markets include those available through wholesale channels as well as direct marketing methods such as U-pick or pick-your-own (PYO), roadside stands, and farmers markets. Direct marketing from the grower to the consumer may be most profitable because intermediary and brokerage fees are eliminated. However, the volume of fruit that can be sold through direct markets is limited by the traffic flow (consumers) to the site of sale. Wholesaling through brokers may move larger volumes of fruit because of sales at many sites, but the profit margin is less.

Match the acreage planted for production to the amount of fruit that can be sold through the desired marketing methods. In the case of acreage for PYO strawberries, Illinois studies have shown that approximately 2,500 people within a 20-mile radius of the point of sale are required to support each acre in production. About 85 percent of your customers will live within 10 miles of the farm. To determine potential for new acreage or increased acreage in an area, draw a circle with a 20-mile radius around your acreage area and then consider the current number of acres in production and the population within the circle. If there are enough or more acres already in production than the population can support, do not plant any more berries. Also consider existing production outside of but near the 20-mile radius of your proposed production site when making a final decision on whether to plant. Successful PYO marketing also requires a good advertising and promotion program.

Consider the availability and ease of acquiring harvest labor along with marketing. The PYO method of marketing eliminates the need for harvest labor, but it still requires some labor for harvest supervision, cashiers, etc. PYO farms began when harvesting labor became scarce and increasingly expensive. The advantages of PYO farms include no harvest labor and transportation costs, improved quality, increased product availability for consumers, and reduced packing costs. Disadvantages are long hours including weekends (you work when customers can come to your farm), difficult customers, liability costs, parking areas, and potential damage to plants and equipment.
Pick-your-own operations require attention to certain factors for successful harvest and marketing, including sufficient quantity of high quality fruit; proximity to population centers; convenient parking area off the highway; and effective advertising notifying customers of berry availability.

The PYO producer should plan to spend a portion of the farm income on advertising through local radio, television, and newspapers, as well as on erecting good signs along major highways to promote the sale of the product. A telephone answering machine that automatically broadcasts a message regarding picking times and directions to the farm can also be a valuable investment.

Growers need to provide adequate equipment, facilities, and instructions for their customers. Check stations should be provided to process incoming and outgoing customers. Generally, growers furnish the picking containers. Someone should be available to give instructions to customers during the picking operations. This will help prevent damage to plants and fruit, reduce customer confusion, and improve grower satisfaction. Studies have shown that the average PYO customer can be expected to pick between 8 and 23 pounds of strawberries per visit. One quart of strawberries weighs about 1.5 pounds. Selling by weight has several advantages, primarily eliminating complaints about over- and under-filled containers. U-pick berries are usually priced slightly below the prices in local supermarkets.

PYO marketing has declined somewhat in popularity in recent years. The following factors have contributed to this loss:

- In many households, both adults work outside the home, resulting in less free time;
- Fewer people are freezing or canning strawberries, so large quantities are not needed;
- Many families have such demands on their time that they prefer to buy prepicked strawberries. Most strawberry producers should plan for a portion of their crops to be marketed as prepicked.

A major drawback of prepicked berries is finding the labor necessary for harvesting. There should be enough pickers to harvest the crop by noon while the fruit are still relatively cool. An average picker can harvest 12 to 15 pounds, or 10 quarts, of fruit per hour. Hired pickers are generally paid on a piecework basis and receive 20 to 25 percent of the selling price. You must charge higher prices for prepicked fruit to pay for the harvest labor. This cost is usually added to the price being charged for PYO berries and passed on to the consumer. It takes six pickers to harvest an acre of matted row strawberries (10,000 pounds or 7,300 quarts) over the season.

Roadside stand operations have developed rapidly and offer possibilities for growers located near population centers. In considering a roadside stand, plan that most of the sales will be local and repeat, rather than tourists passing through. Large quantities usually cannot be handled in this way, but a roadside stand may be very helpful when associated with a pick-your-own operation.

Fruit for the wholesale market normally must be picked firmer and cooled rapidly to reduce perishability during shipping and ensure a good shelf life. Growers who are considering the wholesale market should give special consideration to availability of harvest labor, volume of fruit needed to satisfy wholesale buyer demand, appropriate packaging for attractive display, and cultivars best adapted to shipping. Discussions with produce buyers or brokers prior to planting are highly recommended, because this market is well supplied with a steady volume of produce from large-production states, and the wholesale market may be difficult to enter with locally grown fruit.

Structure Of The Strawberry Plant

The strawberry is a herbaceous perennial plant that is managed in a number of ways that take advantage of its structure and growth habits. A basic understanding of the anatomy of the plant is essential to the effective management of a strawberry planting. Figure 1 shows the anatomy of a strawberry plant.

Types Of Strawberries

Based on their photoperiodic nature, there are currently three types of strawberries: spring-bearers, everbearers, and day-neutrals.

- Spring-bearing types are typically planted in the spring, deblossomed the first season, and cropped the second season. Their growth is phasic in that they flower, fruit, and produce runners, in that sequence. Examples of spring-bearing would include such cultivars as Earlglow, Allstar, and Chandler.
- Everbearing types flower, produce fruit, and then initiate flower buds under the long days of summer. These plants produce two main crops of relatively poor quality fruit in one season.
and frequently their total combined yield of the spring and fall crops does not equal the yield of the single crop from a spring-bearer. Examples of everbearers would include cultivars such as Fort Laramie, Ogallala, and Ozark Beauty.

- The day-neutral strawberry will flower, produce fruit, and produce runners simultaneously. Under Alabama conditions day-neutrals produce a spring crop and a smaller fall crop when air temperatures fall below 80 °F. Examples of day-neutrals would include cultivars such as Tribute, Tristar, and Selva.

### Site Selection And Preparation

Strawberries need full sun for maximum production and should not be planted near wooded areas that will shade the planting. Sites for planting strawberries should be in areas where adequate air and water drainage occur. Sites lower than surrounding land may be subject to frost damage, because cold air is denser than warmer air and settles in low areas (frost pockets).

### Soil Types

Strawberries are adapted to a variety of different soil types, provided they are well drained. Plants usually bloom earlier on lighter soils and thus may increase the need for frost protection. Light or sandy soils are suitable for commercial production when irrigation is available and close attention is paid to nutritional (fertilizer) needs of the crop. Light soils are advantageous because they (1) warm up earlier in the spring than heavier soil types and allow production for the early market; (2) drain well, allowing field work and harvesting sooner after rain than heavier soils; and (3) have fewer root disease problems than heavy soils.

Strawberries are also grown on heavier soils, such as loam, silt loam, and silty clay loam. On heavy clay soils, yields may be reduced because of poor drainage, root diseases, and the resulting poor root development. Soils that are very heavy or extremely sandy, as well as those that are rocky, will be more difficult to shape into uniform raised beds.

### Previous Cropping History

Avoid soils previously planted with solanaceous crops (tomato, potato, pepper, eggplant) as planting sites unless they can be fumigated. Soils previously planted with solanaceous crops may contain a persistent fungal organism that causes Verticillium wilt. If these sites must be used for planting, soil fumigation or planting of Verticillium-resistant cultivars is suggested. Avoid sites recently planted to sod because they may contain large numbers of white grubs, which are injurious to strawberry roots. Also, perennial weeds are frequently a problem on sites that have previously
been in sod or pasture. Delay planting on these sites for at least 1 year after removal of sod or pasture to reduce white grub populations and achieve control of perennial weeds. Ideally land that has been in sod should be cultivated for at least 2 years before planting strawberries.

If perennial weeds (such as Johnsongrass, Bermudagrass, horsernettle, and brambles) are a problem, the field should be treated the year prior to planting with Roundup or other suitable herbicides. Weeds need to be actively growing and green for Roundup to be effective. If sod is present in the planned area, it should be turned over and a cultivated crop such as field corn grown to control grubs and weeds. Soil insecticides and herbicides can be used for corn. After the corn crop, the site can be prepared for a grain crop such as wheat or for strawberries as long as no persistent herbicide such as atrazine has been used. If a residual broadleaf herbicide has been used in the field the previous season, plant a cover crop (green manure crop) for a year to break down the herbicide. Doing so prevents damage to young strawberry plants. The production of a green manure legume crop such as alfalfa, clover, cowpeas, or vetch prior to planting will enrich the nitrogen level as well as supply organic matter to the soil.

**Water Supply.**

An adequate and reliable water source in close proximity to the planting is essential for irrigation and for frost protection. This factor should be carefully considered during the site selection process.

**Soil Testing.**

A soil test should be made at least a year in advance of planting to determine the soil acidity (lime requirement), nutrient levels, and nematode populations. If lime is required to raise the soil pH to 6.0 to 6.5 before planting, it should be applied 1 year in advance. Other nutrients such as nitrogen, phosphorus, and potassium should be applied prior to planting. Your county Extension office can supply you with soil testing kits and information as well as explain your test results.

**Fumigation.**

Soil fumigation is an essential component of the annual hill plasticulture system and has become more important in matted row management with the lack of effective establishment-year herbicides. Situations where fumigation is particularly important include the following cases:

- A strawberry planting must be replanted into an area where they were grown within the past 4 years;
- Fields in which tomatoes, peppers, tobacco, potatoes, or eggplants have been planted within 2 years;
- Where extreme weed populations will make growing strawberries very difficult. Methyl bromide at 240 to 360 pounds per acre, Vorlex at 25 to 40 gallons per acre, and Vapam at 50 to 100 gallons per acre are the three compounds generally used for fumigation.

**Irrigation**

The ability to irrigate is essential in commercial strawberry production.

- Irrigation ensures a good plant stand, maximizes plant growth, increases berry size and total yields, and extends the harvest season by ensuring an adequate moisture supply at all times.
- Sprinkler irrigation may be useful as an effective means of frost protection.
- Irrigation may be useful as a means of incorporating and activating certain herbicides.
- Some fertilizers and pesticides may be applied through the irrigation system, thus reducing the need and cost to enter the field with equipment.
Sprinkler or overhead irrigation is a common form of irrigation used on strawberries growing in frost-prone areas, because of its usefulness for frost protection and plant establishment. Other forms of micro-irrigation such as trickle (drip) are commonly used in plasticulture systems, but trickle does not provide frost protection. The main advantages are a lower water requirement and lower energy requirement to pump the water. The main disadvantages to trickle irrigation are the labor costs to install and the requirement for a clean water source.

Base your irrigation scheduling on plant requirements rather than on the calendar. Tensiometers, gypsum blocks, and data from pan evaporation are used in determining irrigation requirements. Generally, a planting should receive at least 1.5 to 2 inches of water per week during the growing season, either naturally from rainfall or through irrigation. One inch of water applied to 1 acre is equivalent to 27,154 gallons.

**Planting Systems**

Several cultural systems are used in commercial strawberry production in Alabama. The two major systems are the matted row and its variations, and the annual hill.

**Matted Row System**

The matted row system consists of rows 12 to 24 inches wide that are allowed to fill in or be renewed with runner plants (Figure 2). Plants in new plantings should be spaced 18 to 24 inches apart in the row. For maximum yield in the first fruiting season, cultivars with low runner-making ability should be set at 18 inches, while most cultivars may be set 24 inches apart. The more narrow beds (12 to 18 inches) should be 36 to 42 inches between beds, depending on equipment size and slope of the field. For wider beds and steeper slopes, rows 48 inches apart should be considered.

In the matted row system, growers strive for three to four profitable crops from a single planting. With this system, either fall or spring planting dates can be used. Traditionally, early spring has been used for the matted row system. Planting should be completed as early as possible in the spring to allow plants to become established before hot weather. Flowers should be removed the year of planting to allow plants to use food reserves for top and root growth.

Fields are renewed or renovated each year. If properly renovated and maintained, fields planted in the matted row system generally produce three to four profitable crops. If disease, insects, or weeds heavily infest a planting, renovation may not be economically justified. Locate new plantings on a clean site.

*Figure 2. Matted row production system. Note straw mulch between rows to promote clean berries, reduce disease and provide dry walkways for pickers.*
Ribbon Row System

The ribbon row system usually consists of a single row of plants spaced 4 to 12 inches apart on a raised bed with 36 inches between rows. This system is used frequently in more northern states.

The advantages of the ribbon row are the ability to control moisture on poorly drained soil, the exposure of individual plants to a greater amount of sunlight, the higher number of crowns per foot of row, earlier fruit ripening, and easier height of picking.

The disadvantages of ribbon rows on raised beds are that runners must constantly be removed (an added expense), plants are more susceptible to cold injury, beds must be reshaped yearly, and irrigation is a more critical requirement.

Growers considering the ribbon row system should try it first on a small scale to see if it is profitable in their production programs. This concept should apply to all other new cultural practices.

Annual Hill Plasticulture

The annual hill system is a high-density system that grows strawberries as annuals (Figure 3). This planting system consists of closely spaced plants in double rows planted on raised beds covered with black plastic. Plasticulture is an annual system of planting freshly dug plants in the fall. Plants and plastic are removed after spring harvest and the process begins again the next fall.

The advantages of plasticulture are uniform plant stands unaffected by summer diseases, drought, or weed competition; earlier fruit harvest; larger berry size; easier harvest; and shorter turnaround time from planting to harvest (6 months).

The disadvantages of this system are that it requires excellent management skills, higher initial cost, fruit can only be harvested one season before the planting is renewed, and yields may not exceed those of a well-maintained matted row system that has a lower initial cost.

In the annual hill system, plants are typically set from late September through early November. Prior to planting, raised beds are formed using special bed-shaping equipment. The beds are fumigated with methyl bromide-chloropicrin, and a plastic drip irrigation tube is laid down the middle of the bed and covered with a 1.5 mil black plastic mulch. The beds are ready to plant 2 weeks after the fumigants are injected. Usually a two-row bed with a spacing of 12 to 15 inches between rows and between plants down the row is used. Plants are hand-transplanted through the mulch in M-inch slits in the plastic that are cut by trowels or specially constructed spacing wheels. Plants are set so that the crown is level with the surface of the bed. Some root pruning may be needed to shorten
roots to 5 to 6 inches before transplanting. Only undamaged, non-dormant, freshly dug plants with good leaves should be used.

Initiate overhead irrigation within 2 hours after plants are set. These plants will require irrigation varying from a few days to one week. Each morning, start irrigation when plants show moderate wilt and continue to irrigate until the hot part of the day has passed. The primary purpose of these irrigations is to provide sufficient moisture to sustain the plant. Only a relatively small volume of water is required for these irrigations (1/10 inch per hour). Plants should have three or more fully green leaves remaining at the end of the establishment period.

The two major strawberry cultural systems are compared and contrasted in Table 1.

**Fertilization**

**Matted Row Fertilization (New Planting).** At least 10 days before planting, broadcast and incorporate starter fertilizer based on a soil test. The pH should be corrected to 6.0 to 6.5 before planting. Fertilization of new planting should be based on soil test recommendations.

Thirty days after planting, broadcast 30 pounds actual nitrogen per acre down rows (90 pounds ammonium nitrate per acre). This application encourages vegetative growth and early runner development. If a band application is made, be careful to keep fertilizer at least 4 inches away from plants to avoid injury from fertilizer burn.

In late August, broadcast over beds a total of 40 to 50 pounds of actual nitrogen per acre (120 to 150 pounds of ammonium nitrate per acre). A split application 3 to 4 weeks apart is recommended to facilitate more uniform nutrient uptake (60 to 75 pounds of ammonium nitrate per acre can be applied in mid-August and 60 to 75 pounds of ammonium nitrate per acre can be applied in mid-September). These applications are for flower-bud development. Apply fertilizer when leaves are dry and brush off or wash off foliage to avoid fertilizer burn.

On very sandy soils broadcast over the beds 15 to 20 pounds of actual nitrogen per acre (45 to 60 pounds ammonium nitrate per acre) in January. This application influences fruit set and size as well as new foliage development. Winter applications on heavier soils may give larger but softer fruit and may increase problems with fruit rot. Apply fertilizer when leaves are dry and brush off or wash off foliage to avoid fertilizer burn.
<table>
<thead>
<tr>
<th>Practices/Activities</th>
<th>Matted Row</th>
<th>Annual Hill Plasticulture</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yields</strong></td>
<td>5,000 to 12,000 lb. or 3,600 to 8,600 qt./A.</td>
<td>20,000 lb. or 14,300 qt./A.</td>
</tr>
<tr>
<td><strong>Harvest</strong></td>
<td>Generally concentrated over a 2- to 3-week period. Berry size declines as season progresses. Uses Eastern type cultivars.</td>
<td>Harvest is several weeks earlier and season is usually extended to 5 to 8 weeks. Larger and more uniform berry size throughout season. Uses California type cultivars.</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
<td>Typically spring planted and kept for 3 to 4 years. Variable plant stands.</td>
<td>Planted annually in the fall. Uniform plant stands each year.</td>
</tr>
<tr>
<td><strong>Weed Control</strong></td>
<td>Very difficult as there are no good establishment year herbicides. Soil fumigation is a preplant option. Effective weed control in established plantings is also difficult.</td>
<td>Preplant soil fumigation and black plastic mulch.</td>
</tr>
<tr>
<td><strong>Irrigation</strong></td>
<td>Commercial production requires a sprinkler system for irrigation and frost protection.</td>
<td>Requires a sprinkler for plant establishment and frost protection and a drip system for irrigation and fertilizer application.</td>
</tr>
<tr>
<td><strong>Fertilization</strong></td>
<td>Dry fertilizer preplant and periodic fertilization during the growing season.</td>
<td>Dry fertilizer preplant plus nitrogen and potassium injected weekly through irrigation system.</td>
</tr>
<tr>
<td><strong>Renovation</strong></td>
<td>Annual restoration of beds by narrowing rows, thinning out plants, herbicide application, and fertilization immediately following harvest.</td>
<td>Plants are killed with herbicide, plastic mulch removed, and field cultivated soon after harvest.</td>
</tr>
<tr>
<td><strong>Beds</strong></td>
<td>Planted either on flat ground or raised beds.</td>
<td>Planted on raised beds for increased ease of harvest, control of root zone water, and warmer soil temperatures in the spring.</td>
</tr>
<tr>
<td><strong>Soil Surface</strong></td>
<td>Bare ground. May require mulching with straw or pine needles to keep fruit clean.</td>
<td>Black plastic mulch increases soil temperature, keeps fruit clean, helps prevent disease.</td>
</tr>
<tr>
<td><strong>Frost</strong></td>
<td>Must use sprinkler irrigation or floating row cover (thermal blanket) to protect against spring frosts.</td>
<td>Berries ripen several weeks earlier and thus require an extended frost protection period.</td>
</tr>
<tr>
<td><strong>Pests</strong></td>
<td>Diseases and insect pests tend to build up with time. Plants are more susceptible to certain diseases during the hot summer months. Cultivars used have more disease resistance.</td>
<td>Plants are exposed for only a relatively short period to diseases and insects. Cultivars used have little disease resistance.</td>
</tr>
</tbody>
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Table 1. Comparison Of Matted Row And Annual Hill Plasticulture Strawberry Production Systems.
Plasticulture Fertilization.

Where fertilizer injection (fertigation) through a drip irrigation system is not used, all fertilizer must be applied at planting. When fertilizing with drip, all phosphorus (P), micronutrients, and 20 percent of the nitrogen (N) and potassium (K) are placed in the bed at planting. This is typically 30 pounds of actual N. The remaining N and K can be applied in weekly increments corresponding to crop need. The use of soluble fertilizers that may be injected during the season allows for better control of plant nutrition as well as a more efficient use of the fertilizer. Soon after the plants have become established, N and K can be injected during irrigation cycles, typically in equal proportions. From plant establishment until winter dormancy, plants should receive in the range of 5 pounds of N per acre per week. When spring flowering and fruiting begins, plants should receive 6 to 7 pounds of N per week. A total application (both pre- and post-planting) of about 150 units of N per acre will be required each season.

For growers who do not own a fertilizer injection unit, a general recommendation would be to broadcast approximately 500 pounds of 10-10-10 per acre to supply 50 units of N prior to bed shaping. In addition, a 37 percent sulfur-coated urea at 270 pounds per acre may be banded just prior to fumigation (some custom fumigators will also band the slow release N for the grower), effectively supplying another 100 units of nitrogen per acre. Ideally, this is applied in a band approximately 4 inches deep in the bed center. Plantings later than October 1 should not require more than 100 units N (from the slow release fertilizer) for adequate plant vigor and good productivity. An equivalent amount from other slow release sources may also be satisfactory. Recently, there has been a trend to simply broadcast all fertilizers prior to bedding. Some producers have also decided to omit slow release N and use only more soluble fertilizers such as 10-10-10.

Caution:

Using fertilizers with ammonium N in fumigated soils can result in ammonium toxicity to the crop. The grower may wish to use a fertilizer that has at least 50 percent of the N in the nitrate (NO₃⁻) form instead of the initial 10-10-10 broadcast application.

Purchasing And Storing Plants

From a reputable nursery, purchase plants that are certified to be free of insects, diseases, nematodes, and viruses. The extra cost for certified plants is worth the expense when you consider the cost of labor to replant and the delay in harvest that diseased or low vigor plants bring about. Plants should be ordered 1 year in advance to ensure the availability of the desired cultivar.

Inspect plants immediately upon their arrival to determine overall condition and the presence of disease or insect problems. Split a few crowns of dormant plants to see if they have a healthy white color. Check the leaves and roots of freshly dug plants for signs of excessive drying during shipping. If there are signs of damage, notify the nursery immediately. Purchase only freshly dug plants from nurseries that do not have a history of anthracnose-infected plants. In general, the farther north the nursery is located the less likely it is that plants have been exposed to anthracnose.

Matted row dormant plants should be set as early as possible. This enables plants to become established and to produce runners before hot, dry weather arrives. Freshly dug plants should be planted as soon as possible after arrival from the nursery. If plants cannot be set for several days, store them in a cool (32° to 34 °F) moist place. Store plants in their shipping containers to maintain moisture but do not add water because the plants may rot. Freshly dug plants may be lightly misted with water and the shipping boxes reclosed. Most nurseries dig matted row plants while they are dormant and hold them until planting time in cold storage at a temperature of about 30 °F and a relative humidity of 85 to 90 percent. A little ice formation in the crate is not serious, because temperatures must be as low as 21° to 25 °F to cause serious injury to plant tissue.

Storage temperatures above freezing may cause mold, storage rot, and drying. When dormant nursery plants arrive, place them in storage immediately and hold them in the dormant condition until planted. A refrigerator or standard cold storage is satisfactory for holding strawberry plants for a few days.

If planting must be delayed and cold storage facilities are not available, heel-in the plants in a well-drained location protected from both sun and wind. When plant roots are very dry, soak them in water for several hours before heeling-in. To heel-in plants, separate bundles and place the plants in a V-shaped trench that is deep enough to spread out the roots when the crowns are at ground level. Pack soil firmly around the roots and leave plants heeled-in until ready for field planting.
Three basic types of nursery stock are currently being used to establish strawberry plantings.

- The most common stock for matted row systems is the dormant-dug and cold-stored plant that has no leaves, only a dormant crown and root system. These plants are typically dug in early winter, placed in cold storage at the nursery, and shipped at the requested time for early spring planting.

- The fresh, fall-dug plant is dug in early fall and shipped fresh and intact in refrigerated trucks as quickly as possible after digging. Plants are transplanted as soon as possible after arrival on the farm.

- A new choice that has recently become available is called a plug plant. Runner tips with young unrooted plants are clipped in the nursery field. The tips are then placed on vegetable transplant trays with about 60 cells per flat. The flats are filled with commercial potting mix and a runner tip is pressed into each cell. The flats are then placed in a mist bed until rooting is completed. Plants are ready for planting about 1 month after potting. These potted plug plants can be transplanted using a mechanical transplanter.

Plant quality has a definite effect on plant establishment and yield. Do not transplant nematode-infested or diseased plants. Use transplants that are at least $\frac{1}{4}$-inch thick in the crown area. Use plants of several cultivars and obtain them from several sources to reduce chances of large-scale loss. A minimum of four or five leaves per plant is necessary to facilitate the establishment and early growth of fall transplants.

**Cultivar Selection**

Appropriate cultivar selection is vital to the success of any strawberry enterprise. Because strawberry cultivars are extremely sensitive to local conditions, a cultivar that performs well in one location may do very poorly in another area. Cultivars that perform quite satisfactorily in the northern part of Alabama may fail miserably in the southern portion. Because of these differences in cultivar performance, growers are strongly advised to consult with local experts (other successful growers or the county Extension agent) before planting a large acreage of an untried cultivar. It is always advisable to plant a small area of a new cultivar (less than $\frac{1}{4}$ acre) before planting it on a large scale. It is suggested that growers select cultivars with good disease resistance in order to protect against large-scale plant losses.

Cultivars differ greatly in important characteristics such as yield potential, fruit quality and size, and disease resistance. Marketing methods that you will use determine, in part, which cultivars to grow. For shipping, grow firmer cultivars; for PYO, less firm fruit may work out well. PYO growers and consumers prefer large fruit size and open plant habit. Generally, it is desirable to grow at least one early, one midseason, and one late season cultivar to spread out the harvest season. Growing cultivars with different ripening seasons is also a form of income protection if poor weather conditions prevent a good harvest during the ripening period of one cultivar or another. Early season cultivars may ripen 1 to 2 weeks earlier than late season cultivars. Day-neutral cultivars offer the potential for fall fruit production. Matted row and annual hill plasticulture cultivars are two distinct groups that generally do not perform well on a cultural system for which they were not selected. Almost all annual hill cultivars have originated from California breeding programs. New cultivars are continually released, so growers should also check with an Extension specialist before planting large acreages. Tables 2 and 3 contain a description of many of the best cultivars for planting in Alabama.

The number of plants required per acre will depend on the in-row and between-row planting distances selected. Row spacing may be dictated by the equipment used on individual farms. For example, a matted row system planted at 24 inches between plants and 4 feet between rows would require 5,445 plants per acre, while a double row hill system spaced 12 inches in the row and 5 feet between rows would need 17,400 plants. Table 4 shows the number of plants required at various spacings.

**Planting**

**Planting Date**

Traditionally, matted row cultivars are planted in early spring as soon as the ground can be worked. For annual hill culture, freshly dug plants have been successfully transplanted from late September to early November. Earlier planting dates are recommended for northern Alabama, while coastal regions have a much more extended planting season. Those plants that are set earlier tend to grow larger and produce more berries than those set later. On the other hand, later set plants may be more easily picked, have a larger fruit size, and may be earlier ripening.
### Table 2. Matted Row Strawberry Cultivar Descriptions.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Suggested Planting</th>
<th>Season</th>
<th>Yield</th>
<th>Fruit Size</th>
<th>Quality</th>
<th>Disease resistance</th>
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<td>Fresh</td>
<td>Freezing</td>
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*Season: VE = very early; E = early; EM = early midseason; M = midseason; LM = late midseason; L = late; VL = very late; EB = everbearing (day-neutral).

Yield: H = high (15,000–20,000 qt./A.); MH = mod-high (12,000–15,000 qt./A.); M = mod (9,000–12,000 qt./A.).

Fruit size: VL = very large (35–60 berries/qt.); L = large (60–80 berries/qt.); M = medium (80–100 berries/qt.); S = small (over 100 berries/qt.).

Disease resistance: VS = very susceptible; S = susceptible; I = intermediate; T = tolerant; R = resistant; U = unknown; R–S = variable responses in different locations/year.
Plants should be soaked in water prior to transplanting to ensure the best water status for establishment. Mechanical vegetable transplanters increase the speed of planting when more than an acre of plants are to be set. Special care should be taken to ensure that plants are set at the proper depth (Figure 4). Do not bend or twist roots during planting. Transplanters may set plants better when roots are trimmed to 5 to 6 inches and a deep furrow is opened. It is important to have one person follow the planter to ensure that plants are set correctly and to fill in any that are missing.

A spade or shovel or hand trowel can also be used for planting strawberries. Make a V-shaped opening. Insert the strawberry plant with roots fanned out and at the proper depth. Firm soil around the plant with the foot or hand.

Table 3. Annual Hill Plasticulture Strawberry Cultivar Descriptions.

<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Suggested planting</th>
<th>Season a</th>
<th>Yield b</th>
<th>Fruit size c</th>
<th>Fruit firmness d</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chandler</td>
<td>General</td>
<td>E</td>
<td>VH</td>
<td>L</td>
<td>G</td>
<td>Standard of the industry, excellent yield and quality.</td>
</tr>
<tr>
<td>Douglas</td>
<td>Trial</td>
<td>VE</td>
<td>H</td>
<td>L</td>
<td>F</td>
<td>Can be rough and seedy after cold and/or wet weather, very susceptible to anthracnose.</td>
</tr>
<tr>
<td>Parjaro</td>
<td>Trial</td>
<td>E</td>
<td>M</td>
<td>L</td>
<td>E</td>
<td>Very susceptible to anthracnose.</td>
</tr>
<tr>
<td>Selva</td>
<td>Trial</td>
<td>VE (EB)</td>
<td>M</td>
<td>L</td>
<td>G</td>
<td>Susceptible to mite damage</td>
</tr>
<tr>
<td>Oso Grande</td>
<td>Trial</td>
<td>E</td>
<td>H</td>
<td>VL</td>
<td>G</td>
<td>Susceptible to mite damage</td>
</tr>
<tr>
<td>Seascape</td>
<td>Trial</td>
<td>VE (EB)</td>
<td>H</td>
<td>VL</td>
<td>G</td>
<td>May be the best of the day-neutrals.</td>
</tr>
<tr>
<td>Dover</td>
<td>Trial</td>
<td>E</td>
<td>M</td>
<td>M</td>
<td>P</td>
<td>Fruit are too dark. Resistant to anthracnose.</td>
</tr>
<tr>
<td>Sweet Charlie</td>
<td>Trial</td>
<td>E</td>
<td>M</td>
<td>L</td>
<td>G</td>
<td>New release from the University of Florida.</td>
</tr>
</tbody>
</table>

* Season: VE = very early; E = early; EB = everbearer (day-neutral)
* Yield: VH = very high; H = high; M = medium.
* Fruit size: VL = very large; L = large; M = medium.
* Fruit firmness: E = excellent; G = good; F = fair; P = poor.

Plant Spacing

The size of farm equipment and tire spacing must be taken into account when planning the spacing of row centers. Most annual hill systems use a double row with plants typically spaced 12 to 14 inches apart in the row and 14 to 15 inches between rows on a bed. This spacing can be adjusted to compensate for the plant vigor differences between cultivars.

Transplanting

Strawberry plants may be set by mechanical transplanters or by hand. Soil should be worked to a depth of 6 to 8 inches before planting and should contain adequate moisture. If plants are not in plastic bags, the roots must be kept moist. White, secondary roots are killed in less than a minute in hot, dry air. Therefore, it is best to plant on a cool, cloudy, still day, if possible.

Figure 4. Proper planting depth (A) and improper depths (B, C, D). In B, the crown is too deep; in C, the crown is too high; and in D, the roots are bent and remain near the surface.
Table 4. Number of Plants Required Per Acre For Various Strawberry Planting Systems.

<table>
<thead>
<tr>
<th>Planting system</th>
<th>Space in rows (inches)</th>
<th>Distance between row centers (inches)</th>
<th>Number of plants per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mattet Row</td>
<td>12</td>
<td>36</td>
<td>14,520</td>
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<td></td>
<td>12</td>
<td>42</td>
<td>12,446</td>
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<tr>
<td></td>
<td>12</td>
<td>48</td>
<td>10,890</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>36</td>
<td>9,680</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>42</td>
<td>8,297</td>
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<tr>
<td></td>
<td>18</td>
<td>48</td>
<td>5,445</td>
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<td>24</td>
<td>36</td>
<td>7,260</td>
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<td>24</td>
<td>42</td>
<td>6,223</td>
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<tr>
<td></td>
<td>24</td>
<td>48</td>
<td>5,445</td>
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<tr>
<td>Single Row Hill</td>
<td>3</td>
<td>36</td>
<td>58,080</td>
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<tr>
<td></td>
<td>6</td>
<td>36</td>
<td>29,040</td>
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<td></td>
<td>12</td>
<td>36</td>
<td>14,520</td>
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<td>15</td>
<td>36</td>
<td>13,403</td>
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<td>9,957</td>
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<td>Double Row Hill</td>
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<td>26,200</td>
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<td>10</td>
<td>54</td>
<td>23,200</td>
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<td>20,900</td>
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<td>13,400</td>
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Raised Beds

Bedding up the soil helps to prevent flooding damage to the plant roots and also warms the soil up more quickly and thus increases the earliness of harvest. The raised beds also provide easier harvesting of the fruit, because the berries are more accessible to pickers.

The height of the bed varies, depending on the amount of drainage needed. For most growing areas, a height of 7 to 9 inches (measured from bottom of row middle) is sufficient, but higher beds are easier to harvest. The beds are shaped by bed presses, which can be custom-built to provide the desired height and width (Figure 5).

The width of the bed depends on the number of rows desired per bed. Fruit yield per acre may increase with more rows. Production costs, however, also increase because more plants, fertilizer, plastic mulch, fumigant, and pesticides are needed. More rows also result in denser foliage, which may make pesticide application more difficult. Furthermore, beds with more than two rows make picking more laborious and fruit on the inner rows are often missed. The two-row bed is standard in Alabama.

Beds should be made as firm as possible to ensure that they hold their shape and that they adequately retain and conduct moisture. The bed should be shaped so that the center is slightly higher than the shoulder surfaces. This slight central peak will facilitate movement of water from the bed surface and provide an area to which excess fertilizer salts can move. Avoid placing plants in the center of beds, because salt damage may result.

Mulching

Use of black polyethylene mulch as a full-bed cover is a standard strawberry production practice in the annual hill plasticulture system. The mulch improves fumigant effectiveness, retains soil moisture
and fertilizer, and provides higher fruit quality. The black mulch also reduces weed competition and warms the soil (Figure 6).

Use a mulch 0.75 to 1.5 mil thick and wide enough to cover the beds with the edges of the mulch buried by soil. Be sure that the thinner mulches are strong enough to resist tearing throughout the season.

Prior to mulching, the beds are chemically fumigated following all label directions for rate, chisel spacing and placement, and waiting period. The soil must be moist, but not wet, at the time of fumigation and mulch application.

Fertilizer should also be applied prior to mulching. All of the procedures mentioned above can be easily mechanized. A common practice is to shape, fumigate, and fertilize the beds in one operation. Mulch is applied in a second operation. All operations, however, can be done simultaneously with suitable equipment.

**Plant Establishment**

Non-dormant fall transplants require overhead irrigation after transplanting to prevent foliage loss, which reduces plant growth and delays fruiting. These plants will require irrigation for a period of a few days to 2 weeks. Less irrigation is needed for dormant plants and is usually required only to cool the plant and provide soil moisture.

The objective of the irrigation is to prevent foliage desiccation while the plant root system is becoming established. Small amounts of water (1/10 inch per hour) are needed to accomplish this. Irrigation should begin as soon as plants are placed in the ground, with special attention given the first few days after transplanting and to plants with long petioles. Sprinklers should be turned on at the first sign of wilting and turned off when temperatures decrease. Excessive water application from large nozzles, used continuously during the establishment period, can lead to fertilizer leaching and water waste. Research has shown that intermittent irrigation can successfully establish plants with one-half the water consumption of continuous irrigation. Control of the “on” and “off” cycles can be achieved by computers or time clocks. Length of the cycles will depend on weather conditions. However, a 1-minute “on” period and an 8-minute “off” period should be adequate for dry establishment periods, which usually occur in late September and early October.

**Post-Planting Practices**

**Blossom Removal**

For spring-planted, matted row cultivars, all flowers should be removed for the first summer to allow plants to produce runners and a good leaf canopy for next year’s crop. Some of the buds within the crowns of newly set plants are flower buds formed the preceding fall. When the plants begin growth, these buds produce flower clusters. The clusters should be pinched off as soon as they appear (Figure 7). The planting may have to be gone over twice to remove all of the flowers. For day-neutral cultivars (such as Tribute), remove the blossoms for 8 weeks following planting, allowing later blossoms to produce a fall crop.
Cultivation

Cultivation is important to control weeds and to loosen soil so runners may root easily. Cultivate only 1 to 2 inches deep near plants to avoid injury to shallow roots and to prevent bringing to the surface unwanted weed seed. Make passes down the rows in the same direction each time to avoid disturbing runners already in position.

After the rows have sufficiently filled in with daughter plants, attach rolling coulters or use a narrow rototiller to remove any late-forming daughter plants from row middles. A certain amount of hand hoeing is necessary to remove weeds left by the cultivator or herbicides.

Herbicides

Weed control is perhaps the single most difficult task in growing matted row strawberries. Very few herbicides currently are registered for use in strawberries. Timing is critical, particularly in the application of preemergence herbicides.

Strawberries are poor competitors with weeds for light, space, water, and nutrients, making chemical weed control a standard and essential practice in commercial strawberry production. Recommended chemicals and their time of application and rates are given in Circular ANR-0478, “IPM For Small Fruits,” available at your county Extension offices.

Directions for safe use are listed on the product label. Failure to follow label specifications may lead to poor weed control, injury to plants, or possible legal action. Spray equipment should be calibrated before use.

Frost Protection

Strawberry flower buds and fruit are susceptible to frost injury any time after bud break.

Blossoms and berries can be protected by overhead irrigation at a rate of 0.1 to 0.8 inches per hour, depending on wind speed and minimum temperature expected. The principle behind this method is that as water freezes, heat is released by the freezing process. As long as an adequate layer of freezing water covers the bud or berry, the temperature will remain at or near the freezing point (32 °F). The freezing point of water is a couple of degrees above the critical damaging temperature, so proper irrigation will provide several degrees of protection. Detailed frost
protection instructions are available in separate Extension publications.

The use of fabric floating row covers is also a frost protection option for strawberry growers. These synthetic fabrics help to capture more heat during the daylight hours and to partially hold the stored heat that is radiated at night under the cover. The protection provided depends upon the thickness of the material, which is porous to air and water. The lightweight material (0.5 ounce per square yard) provides up to 4 °F freeze protection, while the 0.9 ounce provides up to 6 °F, and the 1.5 ounce up to 8 °F freeze protection. The material, which can be up to 50 feet wide, can be easily pulled over a field prior to an anticipated freeze and removed the next morning to allow for wind and bee pollination of the open flowers. If carefully handled the material should last for several seasons.

**Mulching**

**Overwintering**

In the dormant period, strawberry crowns can be injured by winter temperatures of 20 °F and can be killed outright at 10 ° to 15 °F. The severity of injury depends on cultivar, preconditioning, minimum temperature experienced, and the duration of cold temperatures. Strawberry plantings in the colder northern areas of Alabama may require mulching for protection from temperature fluctuations and soil heaving that can result from freezing and thawing.

Clean wheat, oat, or rye straw or salt marsh hay should be applied in December after herbicide applications. A mulch about 4-inches thick (evenly distributed) requires 2.5 to 3.0 tons of straw per acre. Clay soils require a heavier mulch, as do raised beds. Do not apply mulch in clumps, because this can smother plants.

**Clean Fruit**

Organic mulches are used in matted row plantings to keep the fruit clean and attractive and to help prevent the spread of disease. Berries that develop on top of a clean mulch are less susceptible to disease than those resting on the soil. An additional benefit is realized in that the field is cleaner and the picking aisles are kept drier and less muddy during wet weather. Mulch used in this situation is applied in the
walkways and up under the edge of the developing strawberry plants very early in the growing season. Mulch may also be lightly scattered over the rows in late winter and the plants allowed to grow up through the straw in the spring. An application of 3 tons per acre of pine straw, wheat straw, or other high quality weed-free mulch is typically required.

**Renovation**

With proper annual renovation, matted row strawberry beds can be maintained and remain productive for several years. Renovation is essential because older plants have reduced vigor and overcrowding occurs within the beds, which results in lower yields. Fruit size, quality, and yield decrease when the plant population becomes too great. Only 5 or 6 plants per square foot are needed in the spring for best yields. Disease problems also increase when plantings become too dense, making foliage and fruit slow to dry after rains and more difficult to adequately spray. Renovation thins the beds and invigorates the remaining plants. Thinning to control plant density is important because beds that retain too many plants yield small berries that are difficult to find under the dense foliage. The cost of renovating is considerably less than the cost of setting a new field. The renovation process should begin immediately after harvest is complete. A suggested program includes the following steps:

- **Controlling Weeds At Renovation.** Check the current small fruit pesticide guide for pre-renovation herbicide application recommendations. It is typical to wait 5 to 7 days after herbicide application; then mow off plant tops 1 to 3 inches above the crown without damaging the crown. Set your mower height so that the old leaves are removed but the new expanding leaves are not cut. A rotary mower does a good job. If there are thin areas in the rows, runners should be trained into them before rows are narrowed.

- **Fertilizing The Planting.** A soil test taken several weeks before harvest ends will help determine phosphorous and potash needs. Application of 25 to 40 pounds of actual nitrogen per acre may be made before plants are mowed.

- **Subsoiling (Optional).** Where picker traffic has been heavy in wet weather on clay soil, compacting will be severe. At that time subsoiling between rows may be desirable.

- **Narrowing Rows.** Shortly after mowing (allow the tops to dry), narrow the rows that have become rather wide. This is done by using discs to remove plants from both sides of the row or by using a rototiller with the middle tines removed. Narrow the beds and remove plants, leaving one side of the row so that young daughter plants are retained instead of the older mother plants in the center of the row. Where supplemental irrigation is available to stimulate runner plant development during the summer, rows are commonly narrowed to 6 to 12 inches. If rows are not to be irrigated during the summer, they should be narrowed to a width only slightly less than desired for picking. With plantings that have fruited two seasons or more, growers often cut narrow “slots” in row middles with tiller blades. Because more “quality” berries are usually produced at matted row edges, cutting narrow slots in row centers helps thin middles and gives desirable extra edges.

- **Thinning Plants.** For best production, do not have too many plants in the rows. A heavy plant stand should be thinned enough to allow newly formed plants to be about 5 to 6 inches apart. Extensive hand thinning is not practical on large plantings.

- **Cultivating.** Work in straw between rows and throw a limited amount of soil over the row by cultivation. The controlled application of 0.5 to 1 inch of soil over the plant bed will help produce replacement roots at the very top of the root zone on older plants and help provide a rooting medium for new runner plants.

- **Controlling Weeds.** Preemergence weed control by herbicide application should begin immediately after the preceding steps.

- **Irrigating.** Water is needed to activate weed control materials, to incorporate fertilizers, and to make plants grow. Do not let plants go into stress during summer months. Cultivate to reposition runners into rows until plant stand is sufficient. Aim for production of four to six plants per square foot of row. An eventual row width of 15 to 24 inches will likely provide more marketable fruit than wider plantings.

- **Matted Row Weed Control.** Weeds must be controlled for successful strawberry production. Weed competition can affect both berry size and number, which may severely decrease yields. Weeds also make it harder to pick strawberries and detract from the appearance of the farm. Preplant fumigation with methyl bromide eliminates most weeds but should not be considered...
as a long-term weed-control program. Begin a carefully scheduled herbicide program at planting. Although chemicals do not completely eliminate weed problems, if used properly they make weed control much easier. If used improperly, even approved herbicides may damage strawberries and may be ineffective on weeds. Successful chemical weed control depends upon applying the prescribed amount of the right herbicide at the appropriate growth stage of both weed and strawberry plant. Most strawberry herbicides effectively prevent emergence of seedling weeds, but they do not kill those that are already established. For weed control in a commercial planting, use a four-phase program: (1) site cleanup; (2) preplant soil fumigation; (3) treatments after planting; and (4) cultivation as needed. Hand and machine cultivation is minimized by fumigation and timely use of herbicides but, in most cases, some cultivation will be necessary. Cultivate as needed when weeds become a problem. Do not cultivate for the sake of cultivating—this practice reduces the effectiveness of the herbicide applied before cultivation and exposes weed seed for germination. Consult your county Extension agent for current weed control recommendations on strawberries.

• **Harvesting And Handling.** Generally, berries ripen within 28 to 30 days (as few as 20 days under optimum conditions) after first bloom. Proper picking, grading, and packing are as essential as good cultural practices to success. The harvest frequency and duration depend on weather conditions, cultivars, soil factors, and cultural practices. Strawberries are almost entirely hand picked. Berries can be harvested by hiring pickers or by inviting the public to a “u-pick.” Many growers use the PYO marketing system. However, with an increasing consumer demand for pre-picked berries and for fresh fruit by retail and wholesale outlets, more hand harvest is anticipated by growers. As a general rule for wholesale matted row operations, six to nine pickers are needed for each acre. With annual hill plasticulture systems two to four experienced pickers per acre may be sufficient. For hand harvest, it is wise to employ enough pickers to harvest the berries by noon during the cool part of the day when pickers are most efficient. Harvested berries should be delivered and sold within 24 hours of harvest to reduce spoilage. Six pickers can harvest an acre of matted row berries or about 10,000 pounds over the season. Pickers are paid piecework rather than by the hour. Generally, they are paid 20 to 25 percent of the selling price of the unit they pick. The average picker can harvest 10 quarts (12 to 15 pounds) per hour over the entire season. Under excellent conditions, up to 175 quarts in a 10-hour day may be harvested by the average picker. Because of the ease of harvesting a picker can harvest about three times as much fruit per hour on a raised bed plasticulture system as on a matted row system. Pickers must be instructed by a competent foreman about proper picking (to prevent plant injury), fruit handling, and sorting (grading) in the field. Avoid picking the fruit when plants are wet. Keep harvested berries out of the sun and place them under refrigeration as soon as possible. Pick berries when they are fully colored for optimal size and flavor. **Berries do not improve in quality after picking.** The berries must be picked at the proper stage of ripeness (maturity). Harvest only those berries that are red. Berries still showing white should be left for the next picking. All ripe fruit should be removed to reduce disease problems. The fruit is usually harvested every other day. Quickly place harvested berries in a cool, shady location such as a temporary field shed. The life of strawberry fruit after harvest is short because of high rate of respiration. Firm berries, if precooled to below 40 °F will do well at roadside markets. Berries stored for 7 days at 30 °F will be attractive after remaining at room temperature for 6 hours. Store the berries prefer-
ably at 32 ° to 35 °F and at a 90 to 95 percent relative humidity. Enrichment of the storage atmosphere with carbon dioxide to a 10 to 40 percent level using dry ice will extend the storage life somewhat. Under these conditions, berries should remain salable for 5 to 7 days and losses during shipping, storage, and marketing will be reduced. Pint or quart containers are usually filled in the picking fields and may be covered with plastic film or rigid plastic domes before shipping. The strawberries are then shipped in fiberboard trays that hold twelve 1-pint baskets to prevent damage. An attractive package with the fruit visible will bring premium prices. Growers are strongly encouraged to obtain the Compendium of Strawberry Diseases, which is listed in the following section. The ability to identify major disease and insect problems is essential in effective pest-control programs. The authors gratefully acknowledge the use of materials from the following references in the preparation of this publication.

**Strawberry Pests**

**Soil Insects**
- Whitefringed beetle
- White grubs
- Nematodes

**Soil Diseases**
- Crown rot
- Red stele
- Black root rot

**Above-Ground Insects**
- Mites
- Aphids
- Plant bugs
- Strawberry weevils
- Leafrollers
- Borers
- Thrips

**Foliage and Fruit Diseases**
- Leaf spot
- Leaf scorch
- Fruit rot (gray mold)
- Anthracnose

**Nuisance Pests**
- Fire ants
- Slugs
- Sap beetles
This publication was written by **David G. Himelrick**, *Extension Horticulturist*, Associate Professor; **Arlie A. Powell**, *Extension Horticulturist*, Professor; and **W.A. Dozier, Jr.**, Professor, all in Horticulture at Auburn University.

Use pesticides only according to the directions on the label. Follow all directions, precautions, and restrictions that are listed. Do not use pesticides on plants that are not listed on the label.

The pesticide rates in this publication are recommended only if they are registered with the Environmental Protection Agency and the Alabama Department of Agriculture and Industries. If a registration is changed or cancelled, the rate listed here is no longer recommended. Before you apply any pesticide, check with your county Extension agent for the latest information.

Trade names are used only to give specific information. The Alabama Cooperative Extension System does not endorse or guarantee any product and does not recommend one product instead of another that might be similar.

**For more information**, call your county Extension office. Look in your telephone directory under your county’s name to find the number.

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