Southeast Regional Strawberry Plasticulture Production Guide

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Recommendations of specific strawberry plasticulture practices and cultivars are based primarily on research and grower experiences in North Carolina, South Carolina and Georgia. Because environmental conditions vary widely in the Southeastern United States, growers in other states should be sure to obtain current information about strawberry plasticulture production practices and varieties from their state and county Cooperative Extension center.

I. Introduction

Strawberry plasticulture is an annual hill training system in which freshly dug bare-root plants or plugs (transplants started from runner tips) are planted in late summer to early fall, depending on the climate. Plants are set out in double rows at densities of 15,000 to 17,500 plants per acre. Special equipment is needed to make the 8-inch-deep raised beds that are customarily fumigated with methyl bromide, Telone C-35, or metam sodium and covered with black plastic mulch.

Strawberry plasticulture in northern states is still quite limited, but matted row growers in the Midwest and Mid-Atlantic states are taking a closer look at this production system because it has several advantages, including easier picking and earlier harvesting. Plasticulture berries can be harvested in 7 to 8 months after planting versus 12 months for matted row production. Strawberries grown using the plasticulture system, however, must be intensively managed. Furthermore, daily production and pest management decisions can have a much greater effect on yields and profits than decisions made for matted-row systems. With a plasticulture system, there is considerably less margin for error in regard to soil treatments, timing, pest management, frost and freeze strategies, and marketing.

The strawberry plasticulture production system performs best in the milder areas of the Southeast where temperatures rarely fall below 0ºF (USDA Climate Zones 7 and higher). This isn't surprising. The plasticulture system evolved in the southern states and California. Growers in colder areas in the Mid-South (for example, in the upper piedmont, foothills and mountains of North and South Carolina, and in the Georgia mountains), can also experience success with this method, but they should plan on shorter harvest seasons (no more than five weeks), and yields of about 1 pound per plant (lb/plant), compared to potential yields of 1.5 lb/plant in milder growing areas of the Mid-South and Deep South.

Based on research completed at N.C. State University, strawberry growers need to achieve yields of at least 1 pound of berries per plant, or 15,000 pounds per acre, to make a profit using plasticulture (Safley and Poling, 2004). To achieve these yields, growers need to know the recommended cultivars and practices to use for successful production. This publication provides an overview of the factors that growers in the Mid-South and Deep South should consider before deciding to use the plasticulture system for growing strawberries. It also describes recommended practices for the different stages of plasticulture production, from pre-planting through harvest. (Refer to *Producing and Marketing Strawberries for Direct Markets* by Safley and Poling for in-depth information about the costs and returns of growing, harvesting and marketing strawberries using plasticulture).

II. Preliminary Considerations

Before deciding to use the plasticulture system for strawberries, a grower should consider these factors:

- Site
- Soil
- Equipment
- Plant materials and sources
- Production challenges
- Production time

Site

Attention to specific site selection factors will improve the likelihood of success.

Windbreaks. The most reliably productive strawberry plasticulture sites are almost always those with a wooded area or a windbreak on the north or northwest side of the field.

Row orientation. A north-to-south orientation is recommended for more uniform plant stands and ripening. However, if the field is almost flat, facilitating soil drainage is the most important factor.

Crop rotation. It is best to rotate strawberry field sites as often as possible (see the *Special Note* below), but the general practice in most areas is to crop strawberries continuously on the same land because of existing irrigation lines and market location. Avoid rotations with crops treated with herbicides or plant growth regulators (or a combination of these) that could carry over and cause crop losses in strawberries. Read all pesticide labels carefully for rotational restrictions.

Special Note. If a strawberry field cannot be rotated, summer cover crops should be considered to help reduce soil erosion by keeping the soil covered during high rainfall periods when it would normally be bare. Farmers also report improved soil structure, stability and permeability, decreased crusting, and increased water infiltration from incorporating summer cover crops into the soil before fall planting (see http://www.ces.ncsu.edu/depts/hort/hil/hil-37.html).

Wildlife. Most strawberry plasticulture sites require protection from deer within a month or two of planting.

Soil

Soil content. Strawberries grow and produce satisfactorily in a wide range of soil types, but sandy loam and sandy clay-loam soils are ideal for building and shaping the 8-inch-deep raised beds that are critical to the success of the strawberry plasticulture system. Soils with high clay content or those that are rocky or very stony are more difficult for bedding, fumigation, and plastic-mulch operations. As a general rule, growers should consider using plug plants on soils with a high clay content for semi-mechanical transplanting (with a water wheel) rather than bare-root freshly dug plants (which require hand transplanting). Sandy soils will require more careful irrigation and nutrient management. Heavier clays tend to produce better-flavored fruit.

Soil pH. Optimal strawberry production requires a favorable root environment and the availability of essential nutrients. Soil pH is a key factor in maintaining a favorable root environment. Soils with a pH between 6.0 to 6.2 promote the best growth. A soil test can indicate how much lime is needed. Low pH is one of the most frequent problems identified on soil samples. Because the problem cannot be corrected after planting and low calcium (Ca) usually accompanies a low soil pH, testing and liming the soil as needed is especially important. Incorporate the lime based on the soil test recommendation at least 2 months before transplanting.

Soil moisture. For all soil types and strawberry growing regions in the Midwest, a drip irrigation system is required to meet the moisture requirements of the crop. See the section on "Equipment" for more details.

Soil erosion and surface water management. Although raised beds encourage water drainage within the soil, plasticulture growers frequently encounter problems with getting rid of excess surface water. Because 50 percent of a plasticulture strawberry field is covered with an impermeable plastic film, the field should have enough slope that surface water drains uniformly and gently from the field after periods of heavy precipitation, without causing erosion or leaving puddles. On fields with more than a 2 percent slope (a 2-foot drop in 100 feet), continuous overhead sprinkling for freshly dug plant establishment may cause severe soil erosion. This is why it is often a good idea to broadcast annual ryegrass at a rate of approximately 50 pounds per acre over the entire field the same day you finish fumigating (before planting holes are punched). Ryegrass will reduce soil washing in the aisles after heavy rains or irrigation for establishing freshly dug plants on sloping terrain. Even in colder northern growing areas, the ryegrass should be killed or stunted by an application of post-emergence grass herbicide when it is about 6 inches tall.

Equipment

The following specialty equipment is needed for successful strawberry plasticulture production:

- Unit for shaping beds, laying plastic, and fumigating
- Overhead sprinkler irrigation system
- Drip irrigation system to meet the moisture requirements of the crop

Shaping the beds. New growers should consider hiring a contractor who has the necessary equipment and knows how to use it. Custom applicators can form beds, inject fumigant, apply plastic, and lay trickle tubes in one operation. Where custom services are unavailable for shaping beds, fumigating the soil, and laying plastic, you must either purchase equipment costing approximately $5,500 or make arrangements to lease it.

Overhead sprinkler irrigation. Strawberry plasticulture requires overhead sprinkler irrigation for establishing freshly dug bare-root plants, protecting blossoms from cold injury, and for evaporative cooling during occasional spring heat waves that cause open blossoms to abort. The expense for solid-set irrigation can run from $1,200 to $2,500 per acre, depending on whether cheaper PVC or more expensive aluminum pipe is used. This cost does not include the expense for the diesel or electric pump or for a water supply. It is prudent to plan for at least 12 frost and freeze episodes per season. The water requirement for an overhead sprinkler irrigation system is usually estimated on the basis of three consecutive frost or freeze nights. For example, 5.4 acre-inches of water (27,152 gallons equal 1 acre-inch) would be needed for sprinkling at the rate of 0.18 inch per hour (for control down to 24^{o} F), for 10 continuous hours each night over three nights. Or 1.8 inch per night (10 hours times 0.18 inch) for three nights equals 5.4 acre-inches. An irrigation pond would need to hold about 150,000 gallons of water for each acre of plasticulture production under these conditions (5.4 inches times 27,152 gallons per acre-inch equals 146,620 gallons). Several factors should be considered before installing an irrigation system:

- *Water supply***.** Water may come from wells, ponds, lakes, and municipal lines. An irrigation pond would need to hold about 150,000 gallons of water for each acre of plasticulture production to provide protection on three consecutive frost or freeze nights.
- *Pumping capacity*. A pumping capacity of as much as 90 gallons per minute (gpm) or .2 inches per hour is recommended for severe frost and freeze conditions.
- *Pump*. An electric pump is recommended for reliability if you have a reliable electric power service
- *Sprinkler type*. Low-impact sprinklers are preferred.
- *Sprinkler spacing.* A 40-foot by 40-foot triangular spacing will greatly improve the sprinkling distribution pattern under higher winds as compared to a conventional 60-foot by 60-foot spacing.

Drip irrigation. The deep 8- and 10-inch beds require drip irrigation because capillary movement of water is poor. Drip irrigation provides the most efficient use of water and fertilizer. Many deep wells are fairly clean and require only a screen filter to remove particles. However, the presence of precipitates or other contaminants in the water should be determined by a water-quality test before considering the well for a drip system. Any surface water source, such as a stream, pond, pit, or river, will contain bacteria, algae, or other aquatic life, and sand or special filters are therefore a necessity.

For strawberries, a drip tape is used to wet a continuous strip along the row. A 12-inch emitter spacing is recommended for sandy loam and clay soils. For coarse sands, 8-inch emitter spacing is recommended. Drip emitter discharge rates are generally expressed in gallons per minute (gpm) per 100 feet of length for the selected emitter spacing. A common tape selection for plasticulture strawberries on sandy loam or clay soils uses 0.40 gpm emitters: 24 gallons per hour (gph) per 100 feet. To determine field water requirements in gpm per acre, simply multiply 24 gph times 87.12 (the number of 100-foot row units per acre on 5-foot bed spacing) and divide by 60, which yields 35 gpm.

Because strawberries grown on plastic mulch are considered annuals and are grown for only one season, thin, disposable drip tape (4 to 8 mils thick) is commonly used. Once a drip irrigation system is installed, the crop can be fertilized via the drip system (fertigation). The drip system also can be used to establish plug transplants in the late summer, but some overhead sprinkler irrigation should still be applied for the first two to three days after transplanting (see the section on “Tips and Plugs”).

Once a drip irrigation system is installed, it is possible to fertilize the crop via the drip system (fertigation), as well to protect new root growth in the fall and early spring with chemical injection of mefenoxam (Ridomil Gold) to control infections by *Phythophthora cactorum* (crown rot). The drip system can be used to establish plug transplants in the late summer/fall, but it is still recommended that some overhead sprinkler irrigation be applied for the first two to three days after transplanting.

Plant Materials and Sources

Growers should use that best suit their growing conditions and markets. Plant materials should be obtained from reliable sources that provide disease-free specimens.

Cultivars. Currently, it is possible to grow and successfully market two or three different cultivars for strawberry plasticulture in the Southeast to extend the harvest season over a six-week period. In cooler springs the season may last eight weeks. In hotter years, it can be as short as four weeks. Both Sweet Charlie (early variety) and Chandler (early midseason variety) are widely adapted throughout the Mid-South. Camarosa (a midseason variety) is limited to the milder winter growing areas (such as the coastal plain of North Carolina, South Carolina, and Georgia). A typical pick-your-own and local sales variety "mix" in milder regions where all three varieties are adapted is to have 60 percent Chandler, 30 percent Camarosa, and 10 percent Sweet Charlie. Many growers in South Georgia plant only Camarosa. Although it has inferior flavor to Chandler, it is acceptable for local sales and has the firmness needed for distant shipment if the situation demands. Compared to Chandler, it will also extend the pick-your-own season during the hot south Georgia spring. Sweet Charlie can be used to start the harvest season, but is rarely grown in Georgia because it is relatively low yielding. For piedmont, foothills and mountain regions, Chandler is the most reliable variety and should represent at least 85 to 90 percent of the acreage. In recent years, N.C. State University has released a new variety, Bish (N.C. R 95-08) that compares favorably to Chandler in fruit attractiveness, skin color, and flavor. Bish is anthracnose resistant. However, Bish is not recommend for the coastal plain and is best adapted to more northern and western areas of North Carolina, South Carolina, and Georgia. Other varieties worthy of evaluation in more western areas of these states may include Strawberry Festival. Strawberry Festival is not as productive as Chandler, but in recent trials in western North Carolina, it has been rated highly for fruit flesh firmness and skin relative to Chandler.

Chandler. This is the standard cultivar for the Southeast because of its high yield compared to other plasticulture varieties and because it is well liked by consumers for its good flavor, size, and attractive red color. It should not be planted any closer than a 14-inch in-row plant spacing (for a double-row plant bed on 5-foot center, a 14-inch in-row spacing will require 15,000 plants per acre); it is normal to have a 12-inch spacing *between* the double-rows of plants for standard width plastic mulch beds (28- to 30-inch width on the top). Plugs and freshly dug bare-root plants are usually comparable in yield performance for Chandler, but freshly dugs may have an advantage from the standpoint that they do not concentrate the ripening of the crop as much as plugs in some spring seasons. Optimum plug planting dates for Chandler vary with state and region (freshly dugs should be set three to five days earlier than plugs):

1. North Carolina. These are the optimum planting dates for North Carolina by area:
   - Mountains, high elevation: first week of September
   - Mountains, lower elevation: second week of September
   - Foothills: third week of September
   - Upper piedmont and tidewater: fourth week of September
   - Piedmont transition to coastal plain: first week of October
   - Sandhills: first week of October, but the last week of September is also fine for colder locations, especially for freshly dugs
   - Lower coastal plain: second of week of October or third week for warmer sites. For southeastern counties like Brunswick, it is fine to go as late as the fourth week of October.

2. South Carolina. These are the recommended cutoff dates for Chandler planting in South Carolina:
   - Foothills: September 15

- Upper piedmont: September 25
- Lower piedmont: October 10
- Midlands and upper coastal plain: October 20
- Lower coastal plain: October 25. The immediate coast can be planted as late as November 1, with some effect on earliness (crop will be later).

3. Georgia. These are the optimum planting dates in Georgia:
   - Upper mountains north of the Blue Ridge: late September. Matted row performance might be better in Georgia's upper mountain area north of the Blue Ridge. If the winter is mild, high yields can occur even with late October plantings. However, if the winter is cold, planting outside the best window can result in reduced yields.
   - Piedmont: early October
   - Coastal plain: early to mid-October.

Chandler is quite cold hardy and does not *generally* require winter protection (straw or row covers) for most growing areas in North Carolina, South Carolina and Georgia. However, winter temperatures below 10°F will cause extensive flower and crown injury in this variety. For this reason, row covers are strongly recommended for areas where there is a potential for periods of extreme cold in winter (less than 10°F). Based on recent research with row covers in upper mountain areas (elevations higher than 2,500 feet), it has been determined that row covers (1.5 oz per sq yd) applied in late November to early December for additional winter protection and then removed in early March (before new blossoms reach the "popcorn" stage) can significantly improve Chandler yields compared to unprotected plantings. This climatic zone would include the higher elevations in Georgia. The row covers will also assist with deer protection, and they can be re-applied for cold protection of flower buds and blossoms in late winter to early spring.

Sweet Charlie. For an early market niche, Sweet Charlie is popular. It ripens about five to seven days ahead of Chandler, and possibly two weeks ahead if a row cover is applied in mid-winter. Growers do not generally plant more than 10 percent of their acreage to Sweet Charlie, but in some years the 10 percent of the total crop planted in Sweet Charlie will account for 20 to 25 percent of the operation's profits! The ripening season for Sweet Charlie is rather interesting—it has two weeks of very good quality early production, but then size falls off rather drastically and it does not compete well with Chandler, which is an early-midseason variety. In some years, growers experience a second crop of very large Sweet Charlie berries in the final week of the strawberry season. Many consumers actually show a preference for Sweet Charlie berries, which have a high sugar to acid ratio. Sweet Charlie should be planted at a 12-inch in-row plant spacing (for a double-row plant bed on a 5-foot center, a 12-inch in-row spacing will require 17,500 plants per acre). Optimum planting dates for Sweet Charlie will vary with state and region. But, as a general rule, this variety *must be transplanted at least seven days ahead of Chandler.* Plugs plants are usually preferred for Sweet Charlie over freshly dug bare-root transplants. Field observations suggest that Sweet Charlie may be more susceptible to *Phythophthora cactorum* (crown rot) than Chandler or Camarosa.

Camarosa. The mostly widely planted variety in the world is Camarosa, released from the University of California breeding program. The variety situation in California continues to change as several new releases have been evaluated in North Carolina (including Ventana), but Camarosa continues to be the "new favorite" of growers in the coastal plain of North Carolina, South Carolina, and Georgia. In these warmer winter areas, Camarosa production may soon equal or possibly surpasses Chandler in acreage. Camarosa has not performed as reliably outside of the coastal plain regions, and most growers in the sandhills, piedmont, and foothills have abandoned planting this variety due to low yields relative to Chandler. Row covers may be applied in these areas in early November to enhance floral development and possibly to increase yields. Camarosa fruit is large and very firm, and the plant is vigorous and runners well in summer nurseries. It is quite susceptible to anthracnose, and the same precautions apply as for Chandler (no carryover, use anthracnose-free nursery plants). To achieve the best Camarosa flavor, it is important to delay picking past the glossy bright red stage and to train pickers to harvest Camarosa when it takes on a darker color. However, when it becomes wine-red in color, it is becoming overripe. It is currently believed that the optimum

planting dates for Camarosa are about the same time as Chandler, but most growers prefer to set this variety at least three days ahead of Chandler. Camarosa should be planted at a 14-inch in-row plant spacing (for a double-row plant bed on a 5-foot center, a 14-inch in-row spacing will require 15,000 plants per acre).

Source. The success of a strawberry plasticulture planting, in large part, depends on the health and vigor of the runner tips used for plug propagation. Purchase your runner tips from a reputable supplier. Runner tips must be true-to-variety and free of insects, diseases, nematodes, and viruses. If you are purchasing plugs from a commercial source, be sure to verify that their runner tips came from a reputable supplier. The Web site www.ncstrawberry.org (maintained by the N.C. Strawberry Association, Inc.) keeps a current listing of U.S. and Canadian plant sources of Chandler, Camarosa, Sweet Charlie and Festival.

Plant type and quality. Plug plants are generally more expensive to purchase than freshly dug strawberry plants, but they do have the advantage of being suitable for mechanical transplanting with a water-wheel or disposable pot mulch planter. In contrast, freshly dug plants are most often transplanted by hand. The establishment procedure for highly perishable freshly dug transplants depends on intense overhead sprinkling for one to two weeks, depending on weather, and the condition of the freshly dug plants. Freshly dug plants exposed to cooler temperatures, chilling in the nursery, or both will require less time for establishment than freshly dugs produced in warmer climates. Commercial grower experiences in North Carolina with plug plants indicate that these do require overhead sprinklings for the first, second, and possibly third day following transplanting for approximately 5 hours, 3 hours, and 2 hours per day, respectively.

Plugs versus freshly dugs. Freshly dugs are not usually available until the final week of September, and this is too late for transplanting in colder regions: the upper piedmont, foothills, and mountains of North and South Carolina; the low mountains of Georgia, as in northwest Georgia and the south slope of the Blue Ridge Mountains; and the high mountains within the north slope of the Blue Ridge Mountains. However, if good quality freshly dugs can be obtained in the third week of September, growers in warmer sections of Zone 6 may wish to evaluate freshly dugs from the standpoint of their relative cost savings and the possibility of enjoying a harvest season that is not quite so concentrated in picking.

Plugs are definitely recommended over freshly dugs for part-time growers who do not have the time to oversee the continuous overhead watering of freshly dug plants during the first week following field transplanting. Also, less experienced growers are encouraged to consider planting plugs because they are more "mistake-proof" than highly perishable freshly dug plants. Transplanting dates for plugs can also be slightly later than for freshly dugs without as great a yield reduction. This is because plugs establish more quickly than freshly dugs after transplanting.

"Cutoff" and "frigo" plants. Another type of transplant, called a "cutoff" or "tops off" plant is available in late October from northern California nurseries. These have accumulated considerable chilling in the nursery and have been mowed prior to digging and harvest. Cutoffs are only recommended for the very mildest winter areas in southeastern North Carolina, but not for areas further north or west. They may have some utility in coastal South Carolina and Georgia as well. Based on past research studies, fully dormant or "frigo" plants are not recommended for strawberry plasticulture in any parts of the Mid-South and Deep South.

The success of a strawberry plasticulture planting, in large part, depends on the health and vigor of the planting stock. Purchase your plants from a reputable supplier. Plants must be should be true to variety and free of insects, diseases, nematodes, and viruses.

Production Challenges

As noted in the introduction to this publication, decisions made throughout production can make a big impact on the success of plasticulture strawberries. In particular, the system requires close attention to plant size, density, and weather conditions.

Plant size. Controlling plant size is a very important objective in the plasticulture system regardless of the location. And one of the most important influences on plant size and, ultimately, fruit quality is planting date. Select a planting week for your area that will result in the development of four branch crowns by harvest, in addition to the main crown. Four branch crowns are needed to produce a desirable number of berries per plant (around 35 to 40). But do not plant so early that you end up producing six or more branch crowns per plant. Plants with six or more branch crowns can produce so many blossoms that fruit size will be *depressed* to the point where both harvesting and marketing the small berries will be a problem. Plants that are transplanted late will have inadequate cropping potential due to lower branch crown production. Thus, plant density, planting date, and weather conditions must be considered. By planting slightly later in an unseasonably warm fall, you will encounter fewer problems with plants producing runners. If you find that you are producing more than two to three runners per plant in an "average fall," this is probably a good indication that you are planting too early.

Plant density. Plants are usually spaced at least 14 inches within each row for a double-row plant bed on a 5-foot center. A 14-inch within-row spacing will require 15,000 plants per acre; it is normal to have a 12-inch spacing *between* the double-rows of plants for standard width plastic mulch beds (28 to 30 inches wide on the top).

Table 1. Plant Requirements for Various Row Centers and In-row Spacing (The quantities were calculated based on double-row planting and rounded to the nearest whole number.)

Center	?-inch in-row spacing	?-in in-row spacing	?-inch in-row spacing
5-foot row center	17,500	15,000	13,000
6-foot row center[1]	14,500	12,500	10,089

[1]A 6-foot row center is not usually recommended

Warm fall conditions. Other factors besides the planting date have an important influence on the final number of branch crowns produced. Fall weather conditions following planting in early to mid-September can play a very important role in determining ultimate plant size. Fall temperatures may be so warm as to produce excessive plant size by harvest (more than six branch crowns). In North Carolina, growers who are especially interested in optimizing fruit size and shape will purposely set out a portion of their crop several days to one week later than recommended for their area in case of an unseasonably warm fall. Chandler plugs set at the "normal planting date" may produce two to three runners per plant in a warm fall, and removing these runners can involve a significant labor expense. In colder plasticulture regions in the Mid-South, such as the higher elevations in western North Carolina, it may be better to delay the winter row-cover application until late November or early December if you are experiencing an unusually warm fall season.

Cool fall conditions. If fall temperatures are cooler than usual, you may encounter difficulties in achieving adequate plant size. Plants that end up developing only two or three branch crowns may have a cropping potential of less than 1 pound per plant. If the fall is unseasonably cool, row covers should be applied earlier to enhance plant growth and branch crown formation. In our coldest regions in western North Carolina, the earliest that row covers would be applied is in the last week of October (around Halloween).

Production Schedule

Growing strawberries with the plasticulture system is a year-round activity. Just as berries are harvested in the spring, supplies must be ordered for the coming year so the beds can be prepared in late summer. These activities can be organized into the following stages of production:

- Pre-planting
- Planting
- Post-planting
- Dormancy
- Pre-harvest
- Harvest
- Post-harvest

Table 2 provides an overview of production by month for USDA Climate Zone 6 (where temperatures can drop to 10ºF). Growers in milder areas of the Southeast, where temperatures rarely fall below 0ºF (USDA Climate Zones 7 and higher), will need to take into consideration that the activities shown in Table 2 will occur approximately one to two weeks earlier, depending on growing region and season. A successful harvest depends on the decisions made during production, and timing is essential for success. As noted under "Production Challenges," a bountiful harvest depends on plant size and density, which are directly related to the tasks completed during the pre-planting and planting stages.

Table 2. Plasticulture Strawberry Calendar for USDA Climate Zone 6

STAGE	MONTH	ACTIVITIES
DORMANCY	**January**	Begin a leaf sanitation schedule in late January to early February. Remove dead foliage. Snap off old leaf petioles at their base. Remove any unwanted runners and weeds.
	February	Leaf sanitation must be completed before the onset of new growth from the crown.
PRE-HARVEST		When new growth emerges from the crowns in mid February to early March, roll back the row covers. Leave row covers in the field in case they are needed for a frost or freeze. After new growth begins, pull up side crowns that are caught beneath the mulch. Remove weeds in the planted holes. Hook up drip irrigation within a week or two after new growth has started. Make the first nitrogen fertilizer injection. Check out overhead irrigation system to be sure it is ready for use when temperatures fall and row covers become impractical as plants grow.
	March	Main blossoming period begins 4 to 8 weeks after new leaf growth starts and continues for a month. Inspect plants for botrytis and anthracnose. Begin a control program if needed. Stay alert for conditions that favor frost formation at the ground level. Apply overhead sprinkling for frost protection when row covers become impractical. Maintain a weather journal for future reference. Scout for weeds until harvest.
	April	Make sure a farm liability insurance policy is in effect for pick-your-own and fruit stand operations.
HARVEST		Harvest begins 9 weeks after the first new growth emerges and continues until about 12 weeks after the new growth emerges.
	May	Order tips and plugs for the next growing season by the first of May. Expect the peak harvest around Mother's Day.
POST-HARVEST	**June**	Destroy plants when harvest ends. Incorporate lime when existing beds are broken down.
PRE-PLANTING	**July**	Begin soil preparations. Irrigate overhead to soften soil as needed. Subsoil completely.
	August	Have fumigant cylinders delivered by early August. Check fumigation rig safety. Cut tips for rooting plugs in early August if you are rooting your own. Stick pre-ordered tips or cut tips by mid-August. Broadcast N-P-K fertilizer and disk it into the soil by mid-August. Form and fumigate beds. Lay plastic. Install drip tape.
	September	Inject mefenoxam through the drip system a week before planting if the site has a history of root-pathogenic fungi.
PLANTING/ POST-PLANTING		Transplant and irrigate plugs during the second or third week of September. Put up electric fences for deer protection.
	October	Apply a phosphite-based product (Phostrol, Prophyt, or Agri-fos) to foliage 2 to 3 weeks after transplanting if the plants may be infected with *Phythophthora cactorum* crown rot Check plants carefully for mites 3 to 4 weeks after transplanting. Apply miticide if needed before laying down row covers for late fall and early winter. Check for signs of botrytis crown rot when fall temperatures are warm. Apply strobulurin (Quadris or Cabrio) before temperatures get colder to prevent anthracnose in susceptible varieties. Begin a fertilization program now *if fertilizers were not applied in the pre-plant stage*.

Table 2. Plasticulture Strawberry Calendar for USDA Climate Zone 6

DORMANCY	**November**	Lay a row covering down 5 to 6 weeks after transplanting *if planting is delayed by one or two weeks, if plants are small, or if temperatures are unseasonably cool*. Otherwise, lay down row covering in late November or early to mid-December so plants will accumulate greater winter hardiness. If a row covering is used early in November, stunt the annual ryegrass in the aisles with a post-emergent herbicide before the covers are applied. Check leaves for presence of spider mites and aphids. Take control steps as needed.
	December	Remove runners as needed beginning 6 weeks after transplanting to create 8-inch diameter plants by mid-December with one or two branch crowns and 8 to 10 leaves.

III. Pre-planting

Ensure Fertility: Test the Soil

Complete a soil test several months before planting to determine how much dolomitic lime is needed to raise the soil pH and how much potash (K_20) fertilizer to apply before bedding. If a soil test was not taken prior to shaping the beds, use these standard recommendations: Apply 60 pounds nitrogen (N) per acre, 60 pounds phosphate (P_2O_5) per acre, and 120 pounds potash (K_20) per acre. Broadcast these fertilizers, and lightly incorporate before bedding and fumigation.

Ammonium nitrate is recommended for the pre-planting N application. A broadcast application of 175 pounds per acre of ammonium nitrate will deliver 60 pounds of nitrogen per acre. In general, a P_2O_5 application of 60 pounds per acre should be incorporated even on soil with a high P index. However, on soils that have ultra high levels of phosphorus (typically areas where large amounts of poultry manure have been applied), this application can be deleted. A pre-bedding broadcast application of 120 pounds triple superphosphate (50 percent) can supply 60 pounds of P_2O_5 per acre.

Soil testing also determines the need for potash (K_20). Potassium sulfate is a very good source of K_20 for strawberries (50 to 53 percent), and it provides some sulfur as well (18 percent). If the soil test recommends 60 pounds K_20 per acre, then a broadcast application of 120 pounds of potassium sulfate fertilizer (50 percent K_20) can be applied to meet the crop's potash requirement. Other nutrients can be injected as called for (preferably as the result of tissue testing) through the drip system.

Shape the Beds

Avoid using a vegetable bed-maker. Instead, stick with the bed-making equipment that is specifically designed for deep strawberry plasticulture beds. Reddick and Kennco are two of the leading suppliers. A deep bed will produce higher yields and fruit with less soil splash. The 10-inch deep beds mulched in plastic are typically 30 to 32 inches wide at the base and 28 to 30 inches wide on top. Beds are slightly crowned so water will run off and not rest on the plastic. For example, a bed with a 28- to 30-inch top should slope from the center to the edge with a drop of 1.25 inches. Applying straw mulch to the aisles to keep the berries clean is not necessary with 10-inch deep beds. Bed centers are usually 5 feet.

Most machines have some specific advantages, and it is worthwhile to investigate these differences. Almost all of the machines sold will form the bed, fumigate, lay plastic mulch, and install drip tape in one operation. In general, the single-row bed-making and plastic-laying machines are appropriate for most strawberry operations. Be sure that enough soil is pulled up so that the bed has good, sharp corners and no depression in the center (it is not usually possible to get these sharp corners on clay soils). You may find it beneficial to pre-bed the rows to make sure that enough soil will be pulled up for the bed-shaper—the same disk hillers used for making tobacco beds work nicely for strawberry pre-bedding. The extra pains involved in getting your land "just right" for forming beds, laying plastic, and fumigating will payoff in better plant growth in the fall and winter season and higher yields in the spring.

Install Plastic Mulch

Excellent strawberry beds have the plastic mulch in direct contact with the soil beneath. If there are air pockets beneath the plastic, plant growth will be slow in the fall and winter. Heat from the black plastic will not be conducted into the soil if there are air pockets. In fact, the black plastic will have a cooling effect if it is not in good contact with the soil beneath.

Use embossed 1-mil to 1.25-mil black plastic mulch for strawberry plasticulture production. On 5-foot row centers there are 8,712 linear feet of row per acre, so you will need about 3.5 rolls (2,400 feet) of plastic mulch per acre. For 6-foot centers, 3 rolls of plastic mulch will be required per acre. It is important that the plastic fit tightly on the bed and that the edge of the plastic, or the tuck, be held firmly in the soil. These measures reduce the chance of wind getting under the plastic and causing it to blow off or float up and down, which injures plants.

Install Drip Tubing

Install drip tubing with the orifices facing upwards. The tubing is typically buried 1 or 2 inches deep in the bed center. During installation several workers should be watching to insure that the tubing maintains its orifice-upwards orientation, to assist if the tubing becomes tangled in the injector, and to signal when the drip tape reel is empty. Tubing ends should be closed off by kinking or knotting until the tubes are hooked up to the system. Growers have the option of using only overhead sprinklers in the fall, but the drip system should be functional by late winter.

Fumigate

New land that has been subject to good crop rotations and best management practices (such as cover cropping and good drainage strategies) can, under optimum conditions, generate yields that are 85 to 95 percent of the yields in fumigated soil. Weed control, however, can be a serious problem. Strawberry plasticulture production on the same site year after year is not advisable without pre-plant fumigation because of potential weed and disease problems.

Schedule fumigation far enough in advance to allow for plant-back restrictions for the particular chemical used as well as unexpected setbacks that can occur with weather. If the site is fairly free of noxious diseases and weeds, such as nutsedge, it may be better to plant on time and not fumigate than to fumigate and plant extremely late. Currently, the pre-planting fumigant with the shortest plant-back interval of 14 days is methyl bromide: chloropicrin (67:33). Other registered fumigants for strawberries have plant-back intervals of 21 days or more.

As a general rule, you should begin land preparation for bedding and fumigation at least **six weeks** ahead of planting with the use of methyl bromide: chloropicrin (67:33), and six weeks ahead of planting for Telone C-35.

Stay on Schedule

Here is a sample schedule for a grower in Zone 6 who wants to set out Chandler plugs in the second week of September, and where the producer has decided to use methyl bromide. For fumigants requiring a 21-day plant-back, plan on starting at least one week earlier (also refer to Figure 1).

- **July, week 4.** Whenever there is adequate soil moisture, begin preparing the soil so you can shape the beds and fumigate in early August. In an unusually dry July, you may be forced to irrigate overhead to get the land ready for chisel plowing and sub-soiling, if needed. Sub-soiling is needed every few years on heavy soils. This needs to be done in two directions, north-south and east-west, and it needs to be done deeply to loosen the soil and break up the plow layer (at 10 to 12 inches deep). Breaking up this layer will require setting the draft control so the V-ripper doesn't come up easily when it hits the hard spots. This operation requires extra horsepower! Be sure to incorporate your lime at this stage if you haven't done so already. Ideally the lime should be spread in June, just after the plastic is pulled and the beds are knocked down.
- **August, week 1.** Have fumigant cylinders delivered to the farm, and complete fumigation rig safety checks. Check with your fumigant supplier to be sure the cylinders are delivered on time and to ensure that the proper safety checks are used.
- **August, week 2.** Broadcast N-P-K fertilizers and disk them into the soil to prevent nitrogen loss. Disk to a depth of 6 inches, breaking up clods until the soil has a "fluffy" texture. Don't use equipment that will compact the soil (a rotary hoe or rototiller may cause compaction).
- **August, week 3.** Shape the beds and fumigate with methyl bromide + chloropicrin. Lay plastic mulch and drip tape. As the fumigant is injected, the beds should be immediately "tarped" with an *embossed* 1-mil black plastic mulch film that can be "stretched" by the mulch-laying and fumigation unit to give an extra tight fit over the bed. Also, stick tips (if you are rooting your own plugs). This is also the time to seed annual ryegrass.
- **September, week 2.** Transplant plugs. *Always try to allow three weeks between fumigation and planting*, even though methyl bromide: chloropicrin (67:33) is a two-week plant-back material. This extra week will provide a "cushion" for possible weather delays that may occur. Likewise, for a 21-day plant-back fumigant, you really need to allow a four-week waiting period between fumigation and planting. Thus, fumigation with Telone C-35 should be done in the third week of August for an area that will be planted in the third week of September.

Handle Tips and Plugs Properly

Order runner tips or plugs on time. You must order your tips or plugs well before planting season. Usually, the cutoff for placing these orders is in May. Tips should be shipped to your farm for plug rooting one month ahead of transplanting. For example, tips will need to be cut in the first week of August for transplanting plugs in the first week of September.

Store and handle runner tips carefully. Extended storage of the runner tips is generally not needed. Commercial tip nurseries can harvest fresh tips weekly starting in late July and continuing through mid-October. The tips are shipped by refrigerated truck to the grower's farm for delivery approximately 35 days prior to field transplanting. Tips may be stored up to two weeks at 34^{o}F without deterioration in quality, but you should try to "stick them" as soon as possible after arrival. The boxes containing approximately 1,000 plantlets must be stacked "loose" so that the cool air can circulate freely around the boxes. The strawberry tips are living respiring plants and must be kept cool until the grower is ready to root them under mist. The humidity in the cooler should be kept at around 75 to 80 percent relative humidity.

Root tips with moisture. Prior to rooting tips, additional plantlet preparation is needed to trim away excess runner-cords. An approximate ⅜- to ½-inch runner "stub" serves to anchor the plantlet until new roots develop. Fresh strawberry tips are best rooted under a fine mist that will wet the foliage yet put very little excess water on the soil. Keep moisture on the leaves until the plant is well rooted, about 7 to 10 days. As the roots form, the plants can be weaned from the mist and allowed to draw their moisture from the soil. Gradually reduce the mist over 2 to 5 days. Two weeks after sticking, you should be able to pull most plants from the cell with the root ball remaining intact. When that occurs, misting can be terminated. This is a suggested misting schedule for greenhouse rooting:

- Days 1 – 3: Mist from 8:30 a.m. to 6:30 p.m. for 7 to 10 seconds of mist every 7½ minutes.
- Day 4 – 5: Mist from 9:30 a.m. to 5:30 p.m. for 10 seconds every 7½ minutes.
- Day 6: Mist from10 a.m. to 5 p.m. for 10 seconds every 7½ minutes.
- Day 7: Mist from 10 a.m. to 5 p.m. for 10 seconds every 15 minutes
- Days 8 –10: Mist from 10 a.m. to noon and from 2 p.m. to 5 p.m. for 10 seconds every 15 minutes.
- Days 11 –13: Mist from 10 a.m. to 3 p.m. for 10 seconds every hour. Move the plugs outdoors at the end of day 13.
- Days 14 – 28: Sprinkle for 5 minutes at 1 p.m. and possibly again in the late afternoon if temperatures are high.

Use the right rooting medium. Strawberry plugs should be grown in a specially prepared medium. Many different media are available, but a soil-less media composed of peat, sand, grit, vermiculite, perlite, polystyrene, or other materials is recommended. You will need about 4 cubic feet of media for approximately 1,000 tips, in 50-cell rigid plastic trays measuring 2⅜ by 12 by 20 inches. The 50-cell tray is suggested for small and medium-size strawberry tips. If the tips you receive from your supplier are quite variable in plantlet length, it is well worth the extra step to grade the tips by size into large, medium, and small lots. The large tips should be rooted in 38-cell trays, the medium tips rooted in 50-cell trays, and the smaller tips rooted in 60-cell trays. Sticking large tips (longer than 5 inches) in the same tray with small tips (2 to 3 inches long) will result in light competition and irregular root growth of the smaller, shaded tip plants. During misting, shaded tips are susceptible to botrytis infection.

Acclimate the plants. After the misting cycle is complete, move the trays to a fully exposed gravel pad for another two to three weeks of growth and acclimation before field transplanting. During this final field-conditioning phase, a single daily watering is suggested along with a weekly supplemental drench of a complete fertilizer material. A root-bound plug is desirable for mechanical transplanting; plugs for hand transplanting can be set before this stage is reached.

IV. Planting

Transplanting Plugs to the Field

The ideal age of the plug for field transplanting is four weeks. Plugs held for six weeks in the trays are not as desirable and may have a slower initial growth rate in the field following transplanting. Plug plants pose less serious problems than freshly dugs for field transplanting. Pot-mulch planters or vegetable water-wheels can be used to mechanically transplant and water strawberry plugs. Careful size-grading of tip plants will produce more uniform plugs for efficient machine transplanting.

Depth. Do not "bury" the growing point of the plug plant by setting too deeply. Plug plants are not very deep; the rootballs are only 2¼ inches in depth for 50-cell trays. Your planting hole should not be quite as deep as the plug rootball: A 2-inch hole is recommended for a 2¼- to 2½-inch rootball. Press the plug into the hole so that the top of the rootball is about even with the soil surface. Even if you are mechanically setting plugs with a water wheel, it is a good idea to have one or two workers following the transplanter to brush a light layer of soil around the top of the plug's rootball without covering the growing point. This soil layer is helpful in keeping the plugs from "wicking out." Without this slight soil layer, the exposed artificial soil media will wick moisture out of the plug very rapidly on sunny, windy days.

Starter solution. Tray-grown transplants that have been under a plug propagation nutritional program do not require a starter solution at transplanting. A typical feeding program for plug transplants while they are still in the trays is to apply 1 pound of 20-20-20 per 100 gallons of water (in weeks three and four) before transplanting. This supplies roughly the equivalent of 240 parts per million (ppm) N.

Irrigation. A few hours of overhead sprinkler irrigation immediately following transplanting of plugs is recommended. A number of commercial growers in North Carolina use light overhead sprinkling ($^1/_{10}$-inch per hr) for the first, second, and possibly third day following transplanting for approximately 5 hours, 3 hours, and 2 hours per day, respectively.

Establishing Freshly Dug Plants

The establishment procedure for highly perishable freshly dug transplants depends on intense overhead sprinkling for one to two weeks, depending on weather and condition of the freshly dug plants. Freshly dug plants exposed to cooler temperatures or chilling in the nursery (or both) will require less time for establishment than freshly dugs produced in warmer climates.

Storage and handling. Freshly dug plants may be stored in a cold room at 38°F for 1-2 days before setting; for storage of up to a week, the cooler temperature should be 34°F. Storage for a longer period can make the plants more difficult to establish. Plants in a nursery box or crate are packed tightly enough (typically 500 to 1,000 plants per crate) to make them prone to what is called a "heat," –which makes them unfit for subsequent planting in the field. *It is very important to cool the plants prior to transit*. During hot weather it may be necessary to put plant boxes out to cool more quickly in the cold room, or to run water through the crates to keep plants cool if a cooler is unavailable.

Root pruning. Some root pruning may be needed to shorten roots to 5 to 6 inches prior to transplanting.

Transplanting. The freshly dug strawberry plant is hand-transplanted through the plastic mulch in 2½-inch slits cut by specially constructed spacing wheels that also open a narrow hole for planting. This equipment can reduce substantially the number of hours required to set 1 acre of freshly dug strawberries (approximately 40 hours per acre).

- Do not punch holes through the plastic more than two days ahead of planting.
- Set the plants so that the midpoint of the crown is level with the soil surface.
    - If plants are set too deep, the plants are unthrifty, and crowns may rot and plants die.
    - If planted too shallow, the root system is exposed, which can result in poor rooting and shifting of the plants.
    - The roots must not be J-rooted when set in the planting hole.

Often plants may be set at the right depth, but may either be in a small depression or have soil ridged around the crown. When irrigation is started to establish plants, the depression can fill and bury the crown or the ridge may erode and expose roots. A *firm* plant bed will assist in preventing the bed from settling or eroding. A step-by-step illustrated guide for setting freshly dug plants in English, or Spanish, can be found at:
http://www.smallfruits.org/Strawberries/production/SRnum3Engl_hand.pdf
http://www.smallfruits.org/Strawberries/production/SRnum4Spanish.pdf

Planting innovations. At the summer pre-planting meetings, many growers were surprised to learn that you can achieve a better transplanting job with freshly dugs by using a special hand tool (which is shown in reference 2 below) and a bicycle spacing wheel to mark the holes on plastic (references 5 and 6 below). By transplanting freshly dugs using the "Hill" bicycle wheel system, you can avoid costly planting delays, achieve better weed control, and eliminate the problem of side branch crowns getting caught underneath the plastic in winter.

1. A leaflet on the web that provides guidelines for setting freshly dugs with a hand tool:
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/special/setting_plants.pdf.

2. Information on making a hand tool for setting freshly dugs:
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/sept30/index.htm

3. An illustrated guide for hand setting of freshly dugs with instructions in Spanish:
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/special/SR4_spanish.pdf

4. Pointers on setting freshly dug, bare roots:
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/sept25_03/index.htm

5. Instructions for making a spacing wheel from a bicycle tire rim:
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/sept16_03/index.htm
   Please note that this wheel was featured in *The Strawberry Grower*, July 2005, page 9 (contact name: Ronnie Martin, 919-499-8156).

6. Illustrated guide to planting freshly dugs (more recent):
   http://www.berryalert.org/newsletters/straw/10_4_04.pdf

7. Guide to the dimensions of the special hand planting tool (more recent):
   http://www.berryalert.org/newsletters/straw/10_5_04.pdf

8. Classic article on freshly dug planting that provides a good overview
   http://intra.ces.ncsu.edu/depts/hort/berrydoc/sept13_03_2/index.htm

Bicycle wheels for spacing. There are several drawbacks associated with using traditional freshly dug spacing wheels. In extremely wet seasons, the fields remain too wet for operating any tractor-drawn equipment. Ironically, the same wet conditions that prevent running equipment through the field are generally very favorable for establishing transplants. To avoid further delays in planting, a solution was pioneered by Keith Hill in Smithfield, North Carolina. Hill designed a lightweight unit consisting of two bicycle wheels that are mounted in tandem on a steel frame. This unit can be pulled by hand over the tops of the plastic-covered beds. Unlike tractor-drawn spacing wheels that cause the plastic to stretch and then leave a larger than necessary tear in the film, the bicycle wheel rides over the top of the plastic film. Carriage head bolts protruding through each tire mark the location for planting with just a small hole or prick in the plastic every 14 inches. The bolts are inserted through pre-drilled holes that are spaced to achieve the desired in-row spacing. The bicycle wheels are 12 inches apart (this is the desired spacing between the double-row of plants); and, the wheels are rotated and set to achieve a staggered double-row planting pattern as a worker pulls the unit over the bed top. If you use a 12-inch in-row plant spacing, for example, and also want the wheel to mark four holes per complete turn, then you would need to use a 15.27 inch diameter bicycle wheel (12-inch in-row spacing times 4 holes divided by 3.1416 = 15.27-inch diameter bicycle wheel). With some minor adjustments, this unit also can be used on a conventional freshly dug spacing wheel frame to mark plant holes using a tractor.

Hand tool for setting. A good tool for setting freshly dugs can be made by bending a piece of 3/16-inch thick steel (that is 1-and-3/16-inch wide) at a 90-degree angle such that there is a 4½-inch handle and an 11¾-inch shaft. A notch (going in about ½-inch) is cut into the base of the shaft to aid in catching and holding the bottom of the roots as a worker guides the plant's root system straight down into the soil to a depth of about 5 to 6 inches (depending on root length). A narrow piece of foam is often placed on the shorter end of the tool and wrapped in duct tape for a more comfortable grip. The tool is ideal for setting freshly dugs because it simply makes a slit (no wider than 1½-inch) through the black plastic. The idea is to keep as much of the black plastic intact as possible. Larger holes (such as those made by conventional spacing wheels) will lead to weed competition soon after planting, and side branch crowns will not get caught under the plastic. Many growers are surprised to learn that you can achieve a much better transplanting job with freshly dugs by using this special hand tool in conjunction with the bicycle spacing wheels to mark the holes. An excellent reference with illustrations for using the hand tool can be found at this Web site: http://www.smallfruits.org/Strawberries/production/strbry_Settingplantswithahandtool.pdf.

Irrigating. Start overhead irrigation as soon as plants are set—no more than 30 to 45 minutes should elapse. These plants will require irrigation varying from 7 to14 days after transplanting. Irrigation for the first several days usually begins at no later than 9 a.m. and will run continuously until about 5 to 5:30 p.m. Each morning start irrigation when plants show moderate wilt, and continue to irrigate until the hot part of the day has passed. After several days, irrigation can be initiated a little later in the morning and can be discontinued earlier in the afternoon. Start the 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 *prevent foliage loss until the root system can develop* and absorb sufficient moisture to sustain the plant. Plants should have *three or more fully green leaves* remaining at the end of the establishment period. Only a relatively small volume of water is required for mist cooling. Growers at N.C. State have been successful using 1/10-inch per hour.

V. Post-planting

Monitor the Plants

Plants should have *three or more fully green leaves* remaining at the end of the initial three- to four-week establishment period, regardless of whether they are freshly dugs or plugs. If the "original" leaves on a freshly dug or plug are lost to drought stress, plant establishment will be significantly delayed or "set back" and spring yields will be significantly reduced. The number of leaves and total plant leaf area in the late fall/early winter can be correlated with fruit production the following spring.

Runners that develop in the fall can be removed to prevent competition with crown formation and floral bud development:

- Avoid removing runners until about three to four weeks following transplanting.
- Complete a follow-up runner removal operation at six weeks following transplanting if necessary.

It is also very important to achieve an adequate plant canopy by early winter as a good leaf canopy acts as an important crown insulator in winter. An 8-inch plant diameter is about ideal in mid-December. For good berry production, each plant should form one or two "side stems" (the **branch crowns)** and 8 to 10 leaves by mid-December.

Rooting is active throughout the fall and early winter as long as soil temperature is above 45^{o} F and roots remain healthy. The roots also serve as storage sites for starch reserves during winter. Growers who "push" fall top-growth with extra nitrogen feeding may be doing so at the expense of starch accumulation in the roots. The stored starch is needed for vigorous growth and flowering the following spring, which will enhance berry size.

Ensure Fall and Early Winter Fertility

If beds were prepared as described under "Pre-planting," no fertilizer should be needed after transplanting. It takes strawberry plants (especially freshly dugs) two to three weeks to establish a new root system, and you should not expect the plant's top-growth to look that healthy and vigorous during this initial period. Once a new root system is established, the plants will be able to take advantage of the nitrogen, phosphate, and potash fertilizers that were applied prior to bedding. After three weeks, you should see the plants "color up" and begin to produce healthy new leaves. If pre-plant fertilizers were *not* applied, then it will be necessary to begin a fertigation program starting in the third week following transplanting.

Manage Damage from Wildlife, Diseases, and Pests

Wildlife. Electric fences should be put up no later than the third or fourth week in October to protect succulent new strawberry plants from deer. Yield loss associated with deer depredation can be 50 percent or more in unprotected fields.

Anthracnose. If anthracnose is positively identified in newly established plants, apply a strobulurin (such as Quadris or Cabrio), *before* colder temperatures in late fall to protect the plants from colonization. This treatment can potentially prevent the establishment of an epidemic in anthracnose susceptible varieties like Chandler and Camarosa.

Root-pathogenic fungi. Fungi such as *Phytophthora cactorum* (crown rot) can severely limit root development. If your site has a prior history with this disease or plants have a *P. cactorum* infection, take recommended preventive measures:

- Inject mefenoxam (Ridomil Gold) EC through the drip system a week before planting.
- Make foliar applications of a phosphite-based product (Phostrol, Prophyt, Agri-fos) two to three weeks following planting.

Mites. A miticide application may be needed in the early fall to prevent two-spotted spider mites from reaching damaging levels in the late winter.

- Check plugs carefully for mites three to four weeks after transplanting.
- Make the miticide application before the late fall or early winter application of row covers if row covers are being used for winter protection.

Botrytis crown rot. This disease becomes a concern in unusually warm falls when there can be significant blooming. Botrytis crown rot colonizes the dead flower tissues and moves into the crown.