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BERRY INFORMATION PACKET
VOLUME 3
STRAWBERRIES

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BERRY INFORMATION PACKET

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STRAWBERRIES

1. Production and Imports

The potential for strawberry export from Central America depends primarily on economic factors such as the cost of production, shipping charges and competitive quality and pricing. The cultural adaptability of strawberries to the Central American production areas appears to be quite adequate. Strawberry production technology should be directly transferable from California and Florida to most Central American conditions.

Domestic production in the U.S. is dominated by California which ships around 7,800,000 pounds each year. The primary marketing season for the shipment of California strawberries extends from early March through mid July. Winter fruit is also shipped from Florida at an annual rate of about 1,000,000 pounds. The marketing period for Florida strawberries extends from early December through early May. Additionally, local production is extensive in various regions of the country from May through July. Figures on this pick-your-own, roadside market and home owner production are not available, but estimates suggest that it will rival that of California. The major off season imports come from Mexico beginning at the end of October and continuing through February. Table 1 shows the strawberry production in major states in 1985.

Table 1. Strawberry production in major states - 1935.

State	1000 Tons	Yield per Acre 1000 lbs.
Arkansas	0.9	
California	386.9	53.0
Florida	53.0	20.0
Louisiana	1.5	
Michigan	8.2	6.5
New Jersey	3.1	5.5
New York	8.4	
North Carolina	2.3	
Ohio	4.6	
Oregon	25.2	7.4
Pennsylvania	2.1	
Washington	10.7	7.1
Wisconsin	2.8	
United States	509.4	

Table 2. Major countries which exported strawberries to the U.S. in 1986.

Country	Metric Tons	1000 Dollars
Mexico	4889	4286
New Zealand	751	2468
Canada	146	219
*Guatemala	98	45
*Costa Rica	89	181
Ecuador	45	103
Spain	22	26
*Panama	6	26

Total strawberry imports for 1986 were 5,892 metric tons and were valued at $7,408,000.

2. Production Budgets

No reliable production budgets currently exist for strawberry production in Central America. In this case we must use data from California and Florida and make comparisons on individual farms for production costs and yields in Central America. Production in California extends from February to November with the major shipments being concentrated from March through September. Typical yields average over 50.000 pounds per acre, with varieties such as 'Chandler' and 'Pajaro' producing 4,5000-7,000 trays (12-pints) of strawberries in the first year of production. The 'Aiko' and 'Selva' varieties have the potential of producing 8,000 or more trays per acre. Florida strawberry production averages about 20.000 pounds per acre and extends from November through April. In California about one-third of the acreage is carried over for a second fruiting season.

The cost of production in California is detailed in Appendix 1. A summary of these costs reveal an establishment cost of $7,474.00 per acre based on 10 acres of production. Total cultural costs for a first year fruit harvest excluding harvest costs is $10,509,00. The harvest costs for picking and supervision are estimated at $1.70 per tray, with crates, baskets and wires costing an additional $.83, for a total harvesting cost of $2.53 per tray. Labor costs including fringe benefits and bookkeeping are figured at an hourly rate of $7.20. Total cultural costs for strawberries maintained for a second year were estimated at $3,554,00. Harvest labor costs were calculated at $.18 per pound. In this case, yields of 30,000 pounds per acre would give a total costs of $.30 per pound, while a 50.000 pound

yield would cost $.25 per pound. If total cultural and harvesting costs of about $24, 563.00 are divided by an average production of 5555 trays per acre, the cost per flat is about $4.42. This price excludes shipping and marketing costs.

Estimated operating and ownership costs per acre for strawberry production in Florida is included in Appendix 2. A summary of these costs and returns indicates a total pre-harvest operating cost of $3,895 per acre. Harvest costs were estimated at $1.45 for picking and packing, containers marketing charges at $.50, for a total cost of $3.30 per flat. Additional ownership costs including deprecation, insurance, repairs, taxes and interest on land and equipment was calculated at $1,410.00 per acre. If total salable yield is estimated at 2200 flats per acre the total cost per flat would be $5.71. The labor rate for Florida was calculated at $4.00 per hour, which appears somewhat low when such expenses as social security contributions and workman's compensation are considered. Total costs in the Florida study for operating, ownership, harvesting, and marketing were $12,465.00 based on a production of 20,000 pounds per acre. This study fails to include many of the expenses, inputs, and financial considerations which are more accurately reflected in the California study.

3. **Market Prices**

As is the case with all fresh produce, the prices of strawberries fluctuates substantially with supply and demand. The price per pint of strawberries at terminal markets typically fluctuates between $.60 and $2.50. The lowest prices are usually received during the peak production periods in California form April through the end of August. A representative yearly average is around $1.00 to $1.25 per pint or $12.00 to $14.00 per flat. Any export budget for strawberries from Central America must assume this end price after all cultural, shipping and marketing expenses.

Typical retail prices for I.Q.F. frozen berries are in the $1.39/10 oz. or $2.06/lb. range. Frozen strawberries are currently prices in the range of $1.99/lb. for whole berries and $1.19/lb. for sliced berries. Bulk (5+1 berries + sugar) in 30 gallon containers are approximately $.52-.53 F.O.B. California, and $.56 F.O.B. the Pacific northwest. The cost of shipment to the eastern U.S. is about $.06/lb.

4. Cultural Practices

Standard cultural practices from major production areas such as California and Florida should transfer successfully to Central America. See the attached production guides for details. The use of soil fumigation, raised beds, drip irrigation, plastic mulch, and standard spray schedules should allow for competitive production. The cool climates found at higher elevations should allow for extended flowering of the plants as is found under coastal California conditions.

One important consideration in successful strawberry production is nursery source for planting stock and the chilling and storage pre-treatment which the plants receive. Flowering and vegetables growth of the plants is directly related to their preplanting environment and to the climatic conditions after planting. See California and Florida production guides for details.

5. Cultivars

Cultivar recommendations would include the following: 'Chandler', 'Douglas', Pajaro', and the day-neutral 'Selva'.

Additional cultivars which may perform well in warmer areas include 'Tangi' and 'Cardinal'.

Traditional freezing cultivars include 'Benton', 'Marshall' and 'Fresno'.

6. Market Windows

The best opportunity for export appears to be a market window from August through December.

7. Competitive Market Pricing

In addition to the comparison of production and harvesting costs additional export marketing expenses must be considered. As a general rule air freight will cost about $.25/lb. Additional costs will include customs brokerage, USDA inspection, transportation to warehouse, distributor handling, and distributor commission costs. All of these costs must be factored in when evaluating the potential for export into a well established a very competitive market.

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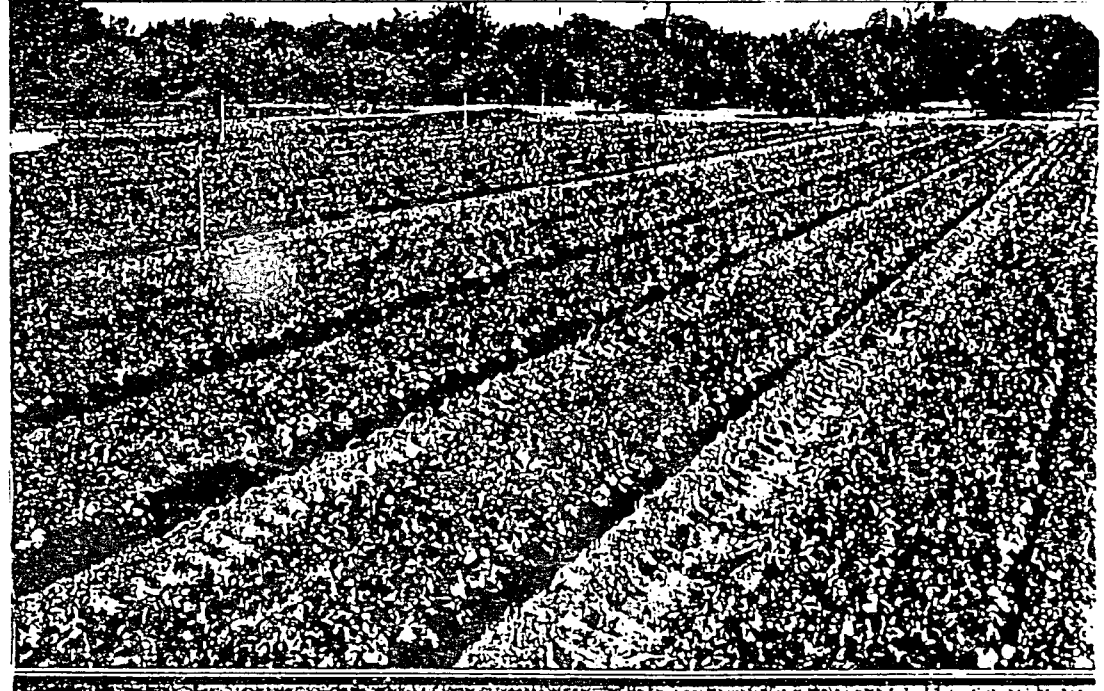

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INTRODUCTION

Commercial production of strawberries began in Florida about 1878 in the Starke and Lawtey area. The fruit were shipped in open crates by rail to the northeastern United States (23). Production began in the Plant City area about 1896 and in southeastern Florida about 1960 (22). The largest state acreage was in 1933 when about 11,000 acres were grown. Production decreased to a low of about 1200 acres in 1975 and then increased to about 5,400 acres in 1983. Although strawberries are grown throughout Florida, about 90 to 95% of the production is located in west central Florida. Strawberries are grown in Florida with the annual hill culture system. Transplants are set during October into well fertilized beds which have been fumigated for nematode and disease control and mulched with black polyethylene. Fruit harvest begins in December and peaks in March or early April. Harvest in local areas may continue until late May. Strawberry fruit are mainly produced for the fresh market and are shipped all over the world, but the largest volume is shipped to the eastern half of the United States. Fruit are also sold through roadside stands, but, near the end of the harvest season, most fruit are sold for processing or to consumers through U-pick operations.

Plants for the fruiting field are produced out-of-state as well as in Florida. The introduction of California cultivars into Florida in recent years has made local nursery production more difficult. Many of the California cultivars are susceptible to a serious disease (30) anthracnose *(Colletotrichum fragariae)*, which can kill large numbers of plants in the nursery and carry over the problem into the fruiting field. Growing these cultivars in an area with a cooler and drier climate helps to control the disease in the nursery (18).

FRUIT PRODUCTION

Planting site selection

Soil Type: Most mineral soils are suitable for growing strawberries. Fine-textured soils or those with spodic horizons (an impermeable soil layer) can be used if good surface drainage is provided. Strawberries are not generally grown on organic soils. All soils, especially the excessively well-drained soils, should have organic matter content in excess of 2% to enhance soil tilth and promote water and fertilizer retention. A vigorous cover crop grown during each off-season can maintain or even slightly increase the soil organic

matter content. As the organic matter content decreases to low levels in the top one foot of well drained sandy soils, the irrigation requirements increase and fertilizer management becomes more critical for the production of optimum yields. On clay soils or soils with higher water tables organic matter content may not be as important.

Drainage: So as to not contaminate the fumigated soil, surface water should not flow into the growing area. Nematodes, weed seed, and disease organisms may move with the water and re-infest the field (20). Drainage, especially surface drainage during the growing season, should be fairly rapid so that plant roots are not damaged by flooding which may occur either after heavy rains or after periods of heavy water application, such as for freeze protection.

Weed Problems: Fields where perennial weeds, such as nutgrass, are a problem should be avoided (27). Attempting to control weeds after planting the crop is difficult and can greatly increase production costs.

Irrigation Water: The water supply may become a limiting resource as urbanization and population density increases. Regulations may limit water use, especially from wells. Irrigation from pits or the re-cycling of drainage water into pits will probably become more common. Irrigation water quality is also important. The water should be relatively low in soluble salts (below 500 to 1000 ppm) (53) and contain no chemicals such as boron at toxic concentrations. If the water pH is near 7 or above, the soil pH will increase, which may require foliar application of some micronutrients (41). Sufficient water pumping capacity needs to be available for freeze protection to prevent flower, fruit, or plant damage (36).

Bed Size

Since strawberries are shallow rooted, most of the roots are within the volume of the formed bed (22), and most of the moisture and nutrient uptake will occur within this volume. The height of the plant bed should be sufficient to permit maximum rooting and to prevent damage to roots during flooding. A bed height of 7 to 9 inches as measured from bottom of row middle is sufficient under most conditions (9). The firmness of the bed can vary greatly depending on equipment used to form the beds. The firmer beds appear to retain moisture longer, but data are not presently available on the effects of bed firmness on plant growth or yield. The width of the bed generally relates to the number of plant rows per bed. As the number of rows per bed increases, the fruit yield may increase, but the harvesting of fruit may become more difficult (8). Pesticide coverage of the more dense plant foliage may also become more difficult which

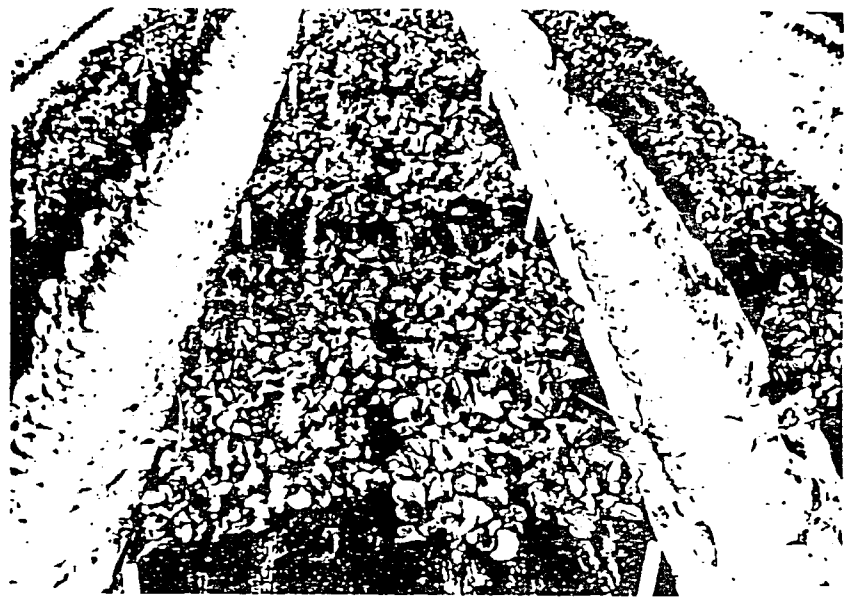

Figure 1. Bed width affects number of rows per bed, plants per acre, production costs, spray coverage, fruit rot, ease of harvest, and fruit yields.

may increase fruit rot. The problems become more important as plant size and density increase and as the length of the fruit stalk decreases (3,5,8). In addition, special equipment is needed for wider beds. Because wider beds cover a greater area, more plants, fertilizer, polyethylene mulch, fumigant, and pesticides are also required. Once the bed width is selected and equipment purchased to fit this bed then the opportunity to change may be limited because of equipment costs (44,46). The potential for increased profits is greater with beds having more than 2 rows because of greater fruit yields (10). However, higher production costs and increased fruit losses because of rots may more than compensate for the greater potential fruit yields (8,10).

Fertilization

Rates: About once every 2 years the soil should be tested for phosphorus, potassium, calcium, and magnesium and the pH determined. Test your soil early so lime can be applied if needed. Several months should elapse between lime (or dolomite) application and bed preparation to allow time for the lime to react with the soil (21). Because of micronutrient availability the pH should be kept between 5.5 and 6.5 (30). Apply phosphorus at the rates recommended by

soil tests. Some 'old' soils have a high phosphorus content and may require only low rates of additional phosphorus. The nitrogen and potassium fertilizer recommendations are made with the knowledge that leaching of these nutrients may be a problem. It is possible to apply rates double those recommended and yet incur a deficiency because of improper fertilizer placement and source and/or excessive irrigation or rainfall and flooding. A soil with a low to medium potassium test level and with most of the fertilizer applied broadcast (mixed in the bed) should receive about 180 to 200 lbs per acre of potassium (all rates of potassium are as pounds per acre of K_2O). With a high soil potassium test level and broadcast placement, 135 to 150 lbs per acre of additional potassium is sufficient. If most of the fertilizer is applied in a band between rows at a depth of 1 to 2 inches, then these rates can be reduced by one-third. Nitrogen should be applied at 175 to 200 lbs per acre depending on the natural fertility of the soil. About one-half of the nitrogen should come from a slow release source, such as sulfur coated urea, IBDU, or a resin coated material (9). The release rate of the nitrogen source must match or exceed the needs of the crop. Consult the Extension agent in your area for recommendations. These nitrogen and potassium fertilizer rates are for 2-row beds. For beds with more than two rows, apply to each additional row the same rate applied per-row with the 2-row beds. Going from a 2-row to a 4-row bed does not double the fertilizer rate. Instead the rate per acre increases by one and one-third because the number of plants and rows per acre generally increases by one and one-third. If 200 lbs of potassium per acre are applied with a 2-row bed system then 267 lbs of potassium per acre would be applied with a 4 row bed system. Remember, that with banding lower rates can be used for potassium. Excessive rates of fertilization, especially with nitrogen may cause excessive plant growth, greater daughter plant production, and increase the problem of albinism. The latter is a condition in which the fruit are normal in size but fail to color properly, are tender in the areas of poor color development, and spoil rapidly after harvest (52).

Micronutrients should be applied to new soils as needed. Leaf analysis during the growing season is the most effective method to determine micronutrient requirements. Table 1 gives the minimum leaf concentrations for various elements. Leaf concentrations should be at or above these levels. If the leaf concentration of an element is below the level indicated in Table 1, foliage application may be required during that season for optimum yields. Soil applications can be made before the next season to alleviate the deficiency. Application of micronutrients to new land seldom exceeds 25 to 40 lbs per

Table 1. **Leaf concentrations needed for optimum yields.**

Nutrient	Minimum leaf concentration
Boron	25 ppm
Calcium	0.3%
Copper	5 ppm[1]
Iron	50 ppm
Magnesium	0.18%
Manganese	30 ppm
Molybdenum	0.5 ppm
Nitrogen	2.8%
Phosphorus	0.2%
Potassium	1.1%
Sulfur	1000 ppm
Zinc	20 ppm

[1]Has been recommended at 10 ppm by one researcher (24)

acre of a micronutrient mix. For most soils, except mucks and alkaline soils, micronutrients, except boron, need only be applied once every 3 or 4 years (14). Manganese and iron are the first micronutrient deficiencies to appear on strawberries in Florida even though substantial amounts may have been applied to the soil. We have observed that as the soil pH nears or exceeds 6.5 most strawberry cultivars on fine sands tend to display a manganese deficiency (13). Foliage rather than soil application may be more appropriate under these circumstances. Since boron may be leached from sandy soils (28), yearly application of boron to the soil or the application of boron to the foliage may be required. Do not apply more than one lb per acre of the element a season to the foliage, and apply in split applications for best results (41). All micronutrient applications can easily become toxic to the plant especially when applied to the foliage. For those who are interested, bulletins with color photographs of nutrient deficiency symptoms of strawberries are available (52).

Placement: Fertilizer should be placed in the polyethylene mulched bed in a manner which minimizes leaching and salt burn and enhances plant uptake. Table 2 illustrates the effect of overhead sprinkler irrigation on leaching of soluble salts from polyethylene mulched beds. Although results varied, the leaching of the fertilizer salts was quite severe. The organic matter content of the soil was about 1%. With greater organic matter content and with slow release fertilizers, leaching would be less. Leaching was less in the center

of bed than under planting holes. Table 3 indicates the effect of depth of placement of the fertilizer band on leaching of soluble fertilizer.

At the time trial was conducted, overhead sprinkler irrigation was not used to establish plants and thus the leaching effects were less. However, levels of soil soluble salts, potassium, and nitrate in the bed with the one inch placement depth were much higher than at the 5 inch depth. Placing the fertilizer deeper in the bed results in it being subject to greater leaching because more water moves through the lower part of the bed during heavy rains and when irrigation is used for plant establishment and freeze protection. A portion of the fertilizer (about one-fourth of the total amount applied) should be mixed in the bed. Although fertilizer placed in this manner is subject to rapid leaching (Table 2), it is needed to provide nutrients to the young transplant for fast early growth. The remainder of the fertilizer should be placed in a band midway between the plant rows and just deep enough to remain in the moist soil during the season (1 to 2 inches deep). As noted, fertilizer placed in this position is least likely to leach (Table 2, 42), and plant roots will feed from the band within 2 to 4 weeks after transplanting (unpublished data). Fertilizer placed under the plant row may cause foliage and root damage or even the death of the plant whether derived from

Table 2. Effect of overhead sprinkler irrigation on leaching of soluble fertilizer from polyethylene covered plant beds[1].

	Soluble salt reading[2]				
	Center		Plant hole		
Treatments	0-3"	3-6"	0-3"	3-6"	Original[3]
Sand no fert	70	98	77	112	126
Sand 2000 lbs/A	595	420	77	182	2800
Sand 3000 lbs/A	525	770	98	770	3850
Sand 4000 lbs/A	448	385	98	322	4900
Soil no fert.	224	210	168	182	322
Soil 2000 lbs/A	1680	1470	112	196	2240
Soil 3000 lbs/A	840	490	154	308	3150
Soil 4000 lbs/A	308	280	168	252	6300

[1]Beds were 2 ft long and wide and 9 inches high in bed center and 8 inches on sides. Ten inches of irrigation were applied over an 8 day period. Four planting hole slits 4 inches long and 6 inches from sides of bed were made in polyethylene mulch for each treatment.
[2]Parts per million soluble salts in saturated extract.
[3]Fertilized with 10-4-10 derived from NH_4NO_3, KCL and triple super phosphate and mixed thoroughly with soil and sand.

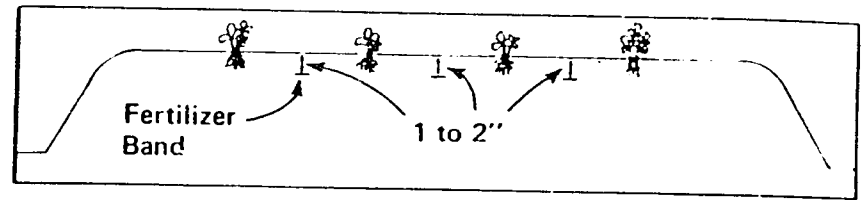

Figure 2. Placement of fertilizer is important to reduce leaching and for prevention of salt burn to plants. Some broadcast placement of fertilizer is needed to hasten early growth.

an inorganic or a slow release source. A common grower practice is to broadcast all of the fertilizer before preparing the plant beds. If too much fertilizer is mixed in the bed or is inadvertently concentrated under the plant row, plant damage from high soluble salts is very likely. Plant damage from soluble salts usually occurs after irrigation for plant establishment ceases. The soil in the bed begins to dry from drainage and from evaporation at the planting slits. Evaporation at the planting slits causes soil water to move towards them. This water carries soluble salts with it which can result in high soluble salt concentrations in the root zone area. This problem has been observed for many years among growers and occurs only when all or most of the fertilizer is mixed in the bed. The testing of large numbers of grower samples at ARC-Dover has shown that when the

Table 3. Effect of placement on leaching of water soluble fertilizer in polyethylene mulched beds.

	Soluble salts (PPM)[1]			Potassium (PPM)[1]			Nitrate (PPM)[1]		
Depth	R[2]	M[2]	C[2]	R	M	C	R	M	C
Inches				1 inch fertilizer placement[3]					
0-2	1015	3785	10140	95	750	2660	175	260	645
2-4	600	1520	4425	50	215	915	150	145	295
4-6	320	795	1095	20	75	165	55	105	90
				5 inch fertilizer placement[3]					
0-2	745	970	1380	15	70	95	35	105	150
2-4	680	495	1085	10	35	115	25	35	80
4-6	870	415	825	15	65	140	20	35	60

[1]Parts per million of soluble salts, potassium, or nitrate in saturated soil extracts.
[2]Soil samples were taken in plant row (R), bed center (C) and one half way between these points (M) on 2-29-68.
[3]Fertilizer placed in a narrow band in bed center either 1 or 5 inches below surface. Fertilizer derived from ammonium nitrate, potassium chloride, and super phosphate.

soluble salt level exceeds 2800 ppm in the root zone of young strawberry transplants foliar wilting and burn can result. The only method available to correct the problem is to apply water with overhead sprinklers until the soluble salts have decreased to non-toxic levels around the plant roots (below 2800 ppm, but the level will vary with cultivar and soil). It has been observed that on well drained sandy soils, especially those with low organic matter content, this practice may result in excessive leaching of fertilizer so that a nutrient deficiency occurs later in the season. If drip irrigation is used, all or part of the nitrogen and potassium may be applied through the drip tube (38). If slow-release fertilizers are used, all the fertilizer can be applied in the bed in a manner similar to that used for overhead irrigation (7). Soluble fertilizer forms placed in the bed and used with drip irrigation may result in leaching of all fertilizer if placement is not proper (7).

Land Preparation and Fumigation

New fumigants and nematicides are made available on a continuing basis. Consult local specialists or the Florida Nematode Control Guide[1] for the fumigant or nematicide most appropriate for your situation and also for the rates to use.

Soil tillage should begin early to ensure that all plant debris will be decomposed before fumigation (30). This requires 6 to 8 weeks and perhaps longer if large woody roots and stems are present. Decomposition can be enhanced with frequent tillage, moist soil, and the incorporation of inorganic nitrogen fertilizer (100 to 200 lbs per acre of ammonium nitrate) into the soil (30). If plant debris is not completely decomposed, nematodes and disease causing organisms in the plant debris can survive the fumigation procedure. Frequent tillage of the moist soil also causes weed seeds to germinate and nematodes to hatch making them more susceptible to the fumigant. The soil should be uniformly moist but not wet at fumigation. Polyethylene mulch should be applied as soon as possible after fumigation. Only the area covered by mulch needs to be fumigated in the fruiting field, and all directions on the product label, especially for application rates, should be followed. Optimum soil temperatures, chisel spacing and depth, and waiting periods before transplanting should be obtained from the label or determined before application. Follow precautions on the label since most fumigants or nematicides are very toxic to humans as well as to soil pests.

[1]Nematode Control Guide. Institute of Food and Agricultural Sciences, University of Florida, Gainesville

Plant Sources and Quality

Strawberry plants can be divided into two classes, dormant and non-dormant, as related to their chilling history in the nursery. Plants which have not been exposed to temperatures below 45°F are non dormant. Plants which have been exposed to temperatures below 45°F will have starch stored in the upper root area. As the number of hours of chilling (below 45°F) received by the plant in the nursery increases so does the root starch content (19). If sufficient starch is stored then the plants are called dormant. This implies that the plant has food reserves (starch) which enable it to survive for long periods in storage at 28°F. Whenever dormant plants are set, growth will be vegetative for several months. A few flowers will appear soon after setting, but no additional flowering will occur for several months. Plants received in the fall from nurseries in the northern United States are usually partially dormant. These plants have sufficient food reserves for establishment in the fruiting field without foliage but not enough for long term storage (19). Vegetative growth is usually quite adequate and fruiting may be somewhat earlier than that of local plants. The time of fruiting and the total yield can be influenced by the amount of chilling that plants have received in the nursery and in storage and also by weather conditions (11). If plants are subjected to an excessive amount of chilling in the nursery or in storage additional fruiting may be delayed and plants may be too vegetative. Plants from northern areas may have inadequate chilling in the nursery before harvest which results in only small amounts of starch in the roots. If these plants are set into the fruiting field with little or no foliage, the response will be similar to non dormant transplants which are defoliated as noted in next paragraph.

Florida-grown plants and usually those grown in the southern United States have received no chilling in the nursery by the normal transplanting date in Florida. Thus starch is not stored in their roots. In addition, placement of bare-rooted plants in cold storage does not result in storage of starch in roots. *These plants should not be defoliated or stored at or below freezing.* Remove plants from the nursery as soon as possible after digging and moisten thoroughly in a stream of clean water. *Do not recycle this water since this may result in spread of diseases or nematodes which may be present.* Plant immediately or place in a cooler for temporary storage. If plants are not removed from the nursery field immediately after digging, bury the roots in *moist* nursery soil but for no longer than two hours (16). Protect plants from desiccation, whether in the nursery after removal from soil, in storage, or in the fruiting field prior to or after transplanting. Desiccation or any other procedure which results in

foliage loss to non dormant plants can result in high plant mortality, slow plant growth and development, delayed fruiting, and reduced fruit yields (4,16). The extent of the problem depends on transplant crown size, amount of foliage retained, and on the treatment the plant receives after transplanting. Plant foliage should be dry when stored for more than a few days in a cooler (30). However, store plants no longer than necessary since storage tends to make plants more difficult to establish (11). If plants are stored for 2 to 4 weeks, establishment is more difficult, vegetative growth in the fruiting field may be excessive, fruiting will be delayed, and total fruit yields can be reduced (11). Plants stored for more than 4 weeks are too vegetative to be set in the fruiting field. Some cultivars may be more adversely affected by storage than others (11). Consult local specialists for information on effect of plant storage on individual cultivars. When plants are stored or shipped, the temperature must be kept low enough and sufficient air must circulate around containers so that plants do not go through a 'heat'. Discard plants which have gone through a 'heat'.

Plants set directly from the nursery into the fruiting field without wilting are easy to establish but tend to be more vegetative than plants which have been in storage for a few days (16). Do not set plants directly from the nursery early in the season (before October 10) since growth can be excessive and fruiting may be delayed, especially when fall and early winter weather is too warm to provide sufficient plant chilling. There is an interaction of photoperiod and temperature in flower initiation (22). The higher the temperature the shorter the daylength required for flower initiation and vice versa (22). This effect varies with the cultivar. Remove excess dead and diseased foliage before transplanting, and inspect plants for nematodes or diseases. When nematodes are present, especially sting nematodes, plants should not be harvested within four to five feet of an infected area (30). If a very light infection of anthracnose is present (a 2 foot diameter area), harvesting of plants 20 feet away from the infection has been satisfactory (29). However, if anthracnose is found anywhere in a nursery, there is always risk involved in setting these plants in the fruiting field. The quality of the transplant determines to a large extent its fruiting capability (1,4,11,16,30). Therefore, use transplants of sufficient size (at least a one-fourth inch crown diameter) which have not been improperly treated prior to transplanting and are anthracnose and nematode free. To reduce the risk of catastrophic loss from diseases, weather, unknown plant defects, and etc., growers usually plant more than one cultivar and obtain plants from more than one source. An additional benefit is that the harvest cycles of the two or more cultivars

Planting Date

Date of planting is influenced by the cultivar, plant quality, and past history of the plant. Except for the day neutral cultivars, plants should not be set before October 5. Non-dormant transplants with little foliage and/or small crowns generally develop and grow slowly and give lower fruit yields (1). If these are used, set them early in the recommended planting period for that cultivar. Generally those plants set earlier in the recommended planting period grow larger and produce more runners and fruit than those set later (11). However, if plants are set too early, especially if fall temperatures are above normal, plants may become too vegetative and fruit production may be severely delayed. If plants are set in the last week of October or later, plant growth is generally less, fruiting is delayed, and seasonal yields may be lower (11,37). High soil fertility increases plant growth, but excessive fertility may result in oversize plants, greater daughter plant production, and possibly poor fruit quality.

Plant Spacing

Spacing of plants on the mulched beds varies with the vigor of the plant (10), and the number of rows per bed (8). On a 2 row bed, the common spacing is 12 inches between rows and between plants down the row. This spacing normally allows sufficient air circulation around plants, fairly good penetration of spray material, and enables fruit harvesting to proceed quite rapidly since fruit are more visible. With 3 and 4-row beds, the distance between rows varies from 8 to 11 inches. Most growers using more than 2 rows per bed increase the spacing between plants down the row to compensate for the decreased spacing between rows. The harvesting of fruit from beds with more than two rows per bed is more difficult, especially as the plant density increases (5,8). As plant density increases with any row number per bed more fruit are missed by the picker and left to rot. In addition, fruit rot is also increased because fruit under the foliage stay moist longer during the day and pesticide spray coverage may be reduced (5,8,10).

Fruit yields can increase with increased plant density, but losses from fruit rot may lessen the advantage of increased density (10). Increased plant density also means more pesticide spray may be required to control diseases, mites, and insects. The number of rows per bed and the spacing between and down the rows is largely determined by the grower's management ability, equipment, especially spray equipment, and the quality of the crew harvesting the fruit.

Planting Depth

The diagram shown in Figure 3 illustrates the proper planting depth for strawberries. If plants are set too deep, the plants are unthrifty and the crowns may rot and the plants die (22,25,50). If planted too

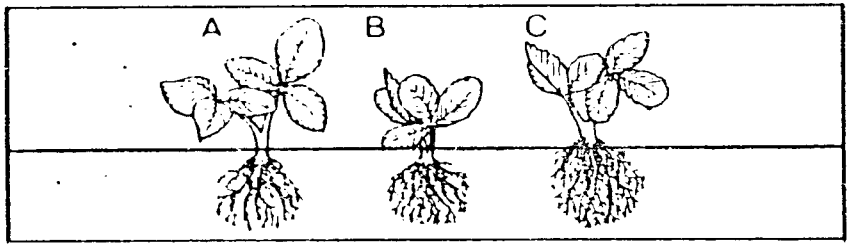

Figure 3. Correct planting depth is important for proper rooting and to avoid plant damage or mortality. A is the proper depth, while B and C are too deep and too shallow, respectively.

shallow the root system is exposed which can result in poor rooting and shifting of the plant in breezes or when harvested (22,25,50). Often plants may be set at the right depth but either be in a small depression or have soil ridged around the crown. When irrigation is initiated to establish plants, the depression can fill and bury the crown or the ridge may erode and expose the roots. A firm plant bed assists in preventing the bed from settling or eroding.

Establishing Plants

Plants without adequate starch in roots require overhead sprinkler irrigation to prevent foliage loss and plant mortality. These plants will require irrigation varying from a few days to 2 weeks after transplanting (4). Initiate irrigation as soon as plants are set. Each morning start irrigation when plants show moderate wilt and continue irrigation until the hot part of the day has passed or until wilting conditions are no longer present. After a few days, irrigation can be initiated a little later in the morning and can be discontinued earlier in the afternoon. Plants should have 3 or more leaves remaining at the end of the establishment period. Excessive foliage loss delays growth and fruiting (4,16). Dormant or partially dormant plants do not require irrigation to the extent of non-dormant plants. Irrigation for dormant or partially dormant plants is provided to cool the crowns and for moisture.

The purpose of the irrigation is to prevent the desiccation of the plant foliage until the root system can develop and absorb sufficient moisture to sustain the plant. Only a relatively small volume of water is required. However, the irrigation system generally used by the grower is designed to provide large volumes of water. This results in excessive water use and leaching of fertilizer from the plant beds. One method to reduce the amount of water applied is with intermittent irrigation. Irrigation is applied for a few minutes and then stopped for a few minutes. Control of the intervals can be obtained with time clocks and solenoids or with other devices. The following is a list of some of the practices required for the successful use of intermittent irrigation to establish plants. Some items (1,2,3,4,5,10,11,13) apply for continuous irrigation also.

1. Use plants with short petioles when possible.
2. Set plants as soon as possible after digging from nursery.
3. Do not allow plants to wilt from time of digging from nursery until irrigation is initiated after transplanting.
4. Use only healthy plants and remove dead leaves.
5. Turn irrigation on as soon as plants are set.
6. Thoroughly moisten transplants and mulch during the time the irrigation cycle is "on". This usually takes at least 5 minutes of irrigation.
7. Resume the irrigation "on" cycle by the time plants become dry.
8. Length of "on" cycle varies with climate; (a) hot, windy, and dry weather results in longer "on" and shorter "off" cycles, (b) during cool and moist weather little irrigation may be needed.
9. Plants should not be permitted to wilt excessively during the "off" cycle.
10. Turn irrigation system "on" in the morning when plants begin to wilt.
11. Discontinue irrigation in the afternoon when it appears that plants will not wilt excessively for the remainder of the day.
12. If leaves start to become necrotic, difficult to moisten, or cling to plastic mulch, then either not enough water is being applied or the "off" cycle is too long.
13. The first few days after plants are set in field are more critical to establishment than the period after this time.
14. Response to intermittent irrigation varies with the variety used and the condition of plants within a variety. Plants with long petioles and those which are wilted, diseased, etc., will require more irrigation and care.
15. As a guide to the length of the "on" and "off" periods, a 7 minute on with a 8 minute off cycle should be sufficient under the most arid conditions encountered during the strawberry planting season. This most arid period is usually in late September and early October. Poor quality plants may cause one to shorten the off cycle a minute or so.

16 Less fertilizer was leached with intermittent irrigation than with continuous irrigation in studies at ARC-Dover (unpublished data). In one experiment, high rates of fertilizer applied broadcast resulted in foliage burn with intermittent but not with continuous irrigation during establishment. Thus proper fertilizer placement and low rates of broadcast fertilizer are important with use of intermittent irrigation.

17 Intermittent irrigation should reduce water consumption for establishment by one half.

Daughter Plant Removal

Daughter plant (runner) production in the fruiting field varies depending on the cultivar, chilling history of the plants, and the planting date. The more chilling a plant receives prior to setting in the fruiting field, especially chilling received in storage, and the earlier the plant is set the greater the runner production (11). A few days of very cool weather (night temperatures near freezing) in the fruiting field tends to reduce or eliminate further runner production. Runner production is undesirable in the fruiting field because the excessive plant growth interferes with harvesting and pesticide application (3,5,8), but more importantly the plant's food reserves may be used for unwanted vegetative growth and not for fruit production. Runners can be removed manually, or, as in other areas

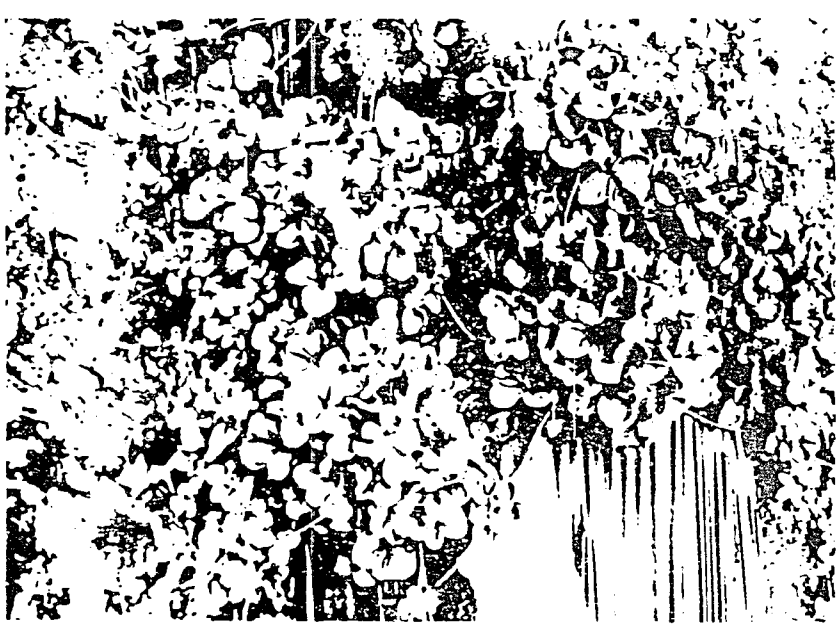

Figure 4 Production of daughter plants in the fruiting field is undesirable.

of the U.S., by suction type rotary mowers when runner plants are not rooted (32,49). Sometimes the runner plants are set into places where the original plant has died. These appear to flower earlier than a normal re-set and establish without additional irrigation if not removed from the mother plant for a few days after setting. Of course, fruiting is delayed and yields are reduced with re-sets (unpublished data).

Weed Control

Weed control can be enhanced by proper choice of fumigant, by cultivation, and by use of herbicides. The broad spectrum fumigants provide some weed control while nematicides do not. Weeds are controlled to a large extent in the bed by the black polyethylene mulch; however, weeds do grow through the plant holes. These weeds are generally controlled by hand weeding but may also be controlled by herbicides. Care must be taken with the application of herbicides to strawberry plants since plants may be injured and growth slowed with their use (12). Weeds in row middles can be controlled with a combination of cultivation and herbicides. Herbicides must be labeled for use on strawberries and applied in a manner that does not harm the plant or leave excessive residue on the fruit. Remember that herbicides applied to the row middles may be absorbed by strawberry roots growing in the row middles or the herbicide may move laterally under the plant bed with the soil water.

Irrigation

Strawberries are shallow rooted (22) with most of the roots located in the top 8 to 10 inches of the soil but with some root penetration to a depth of 24 inches (22). Some root development usually occurs in the row middles. Since strawberries are grown on a range of soil types, irrigation frequency and rates are related to the water holding capacity and drainage characteristics of the soil. In addition, rainfall, air temperature, and plant size also influence the amount of irrigation needed. For sandy well-drained soils, with 1 to 6% organic matter, the soil moisture content within the bed should be within a range of 7 to 10%. This is wet enough so that when squeezed into a ball the soil will retain its shape and feel moist but water droplets will not form on or drop from the ball. Almost all irrigation for moisture is by overhead sprinkler. This method is required for plant establishment and frost protection. If drip irrigation is used for moisture, water should be applied to the beds daily at or near the pan evaporation rate for the area covered with mulch (7,43). If one half the field is covered with mulch and the pan evaporation rate is 0.1 inch per day, then 0.1 inch drip irrigation should be applied to an acre of bed area or two acres of field area. The greatest water

requirement period is in March and April when high air temperatures increase evaporation and transpiration. Plant beds should be checked on a daily basis during this period to prevent plants from becoming desiccated. Various types of equipment are available to assist in monitoring the soil moisture level. Fruit quality and size deteriorate if plants do not have sufficient water (7). Excessive water use with drip irrigation can result in excessive fertilizer leaching (39).

Cold Protection

When plants in the fruiting field begin to flower, protection from freezes should be available. Overhead sprinkler irrigation is the usual method for freeze protection. The irrigation water provides heat to the plant as the temperature of the water drops to 32 °F and especially as it freezes. As long as the temperature of the flower or fruit stays above 30 °F no damage results. The lower the air temperature the greater the amount of water needed to maintain the temperature of the flowers and fruit above the damaging level (36). Open strawberry flowers are more prone to freeze damage than green fruit which, in turn, are more sensitive than ripe fruit (unpublished data). Flowers and fruit are more sensitive to cold damage after several weeks of warm weather than after several days of cool weather.

Figure 5. Overhead sprinkler irrigation can protect flowers and fruit from freezes if proper procedures are followed.

Irrigation need not be turned on until the temperature in the coldest area of field, just above the mulch, open to the sky, and not protected by nearby plants or objects is about 31 °F. Irrigation should be discontinued as soon as the ice *begins* to melt on the foliage or when the wet bulb temperature is above 32 °F (36). Spacing of sprinklers should be such that, without a breeze, the water from each sprinkler reaches all adjacent sprinklers. If wider spacing is used, protection may not be adequate under windy or very cold conditions. If the wind speed is high (10 to 15 mph or greater), water application even with close sprinkler spacing may be spotty and erratic. Under these conditions plants as well as the flowers and fruit may be severely damaged. With little or no wind, about 0.15 inch per hour of irrigation is required for frost protection down to a temperature of 22 °F and about 0.25 inch per hour from 22 °F to 18 °F (36). If irrigation water is taken from a pit, the water is generally colder than that from a well, and greater amounts may be required for protection. Further information on cold protection can be obtained from Florida Extension Circular 348, "Sprinkler Irrigation for Cold Protection."

Harvesting and Marketing

Most of the strawberries harvested in Florida are shipped fresh to northern markets from December through April for immediate sale. To obtain a high quality product, fruit should be less than three-fourths full-color when harvested (40). Fruit that are fully ripe are easily bruised and deteriorate or decay in transit. Discard overripe fruit or those with decay spots, since any decay can easily spread to adjoining fruit (40). Since strawberries are highly perishable, the fruit should be cooled immediately after harvest. Fruit should be cooled to just above freezing by forcing cold air through the packing crates (40). Fruit quality is lost rapidly if exposed to warm temperatures for even a short time. It has been stated that the loss of fruit quality at a temperature of 85 °F for one hour is about equivalent to one week at 32 °F (26). During warm weather, extra efforts should be made to cool fruit immediately after harvest. Towards the end of the harvest period, usually in early April, the fresh market shipping season ends. Fruit for the remainder of the harvest period are either sold fresh to local markets and to processors or are U-picked.

Ease of harvest is influenced by foliage density, fruit size, length of fruit stalk, and how strongly the fruit clings to the stem. Harvesting of the fruit, generally, is directly into the shipping flat. Some grading is done in the packing shed to remove any undesirable fruit from the flat. Rows should not be so long that pickers spend

an inordinate amount of time carrying flats from field to packing shed. Packing sheds can be located on both ends of rows to shorten carrying distance.

Malformed fruit can be a problem in Florida and its severity varies with the year, the cultivar, the grower, and even the particular field. Malformed fruit are the result of incomplete pollination of the strawberry flower (22). The extent of the malformation is closely related to the number of pistils on the flower that are not fertilized (22). There are many reasons for malformed fruit. On some cultivars, the number of malformed fruit increases as the temperature rises above 104°F because of decreased pollen activity (51). Fungicides sprayed on day of flowering can inhibit pollen germination and cause malformed fruit (51), as can lack of pollinating insects (51). Other causes are frosts or freezes, cold but not freezing temperatures accompanied by wind and/or rain, parasite damage, overcrowded plant beds, fungi, cold soils, and, with some cultivars, poor quality pollen (33,34). Additional causes are herbicide injury, the tarnished plant bug, boron deficiency, and localized rot caused by blossom petals adhering to fruit (45). A *Rhizoctonia*, sp. fungus can cause malformed fruit (31), as can high N (17), low levels of foliar zinc and copper (24), and larvae of army worms and other insects feeding on flowers. Boron levels in the young but fully expanded foliage should be 25 ppm or greater, and the zinc and copper levels are recommended to be above 20 and 10 ppm, respectively (24). Determination of the cause of malformed fruit can be difficult since the damage is often not noticed until days or weeks after it occurred and the causal agent may no longer be present.

Controlling Diseases, Insects, Mites, and Nematodes

Consult the bulletin, "Diseases, Nematodes, and Insects Affecting Strawberries in Florida" (in preparation) and the latest pest control guides available from your local Extension office. These contain illustrations of strawberry pests and the latest information on pesticides available, rates to use, instructions for application and any restrictions on their use.

Strawberry Cultivars

New cultivars are released on a continuing basis. Consult your local Extension agent for varieties adapted to your area and which are best for local market use, for shipment out of state, or for the home garden.

NURSERY PRODUCTION

Selecting the Soil Site

For soil type, drainage, weed problems, and irrigation water see the Fruit Production selection.

Natural Fertility: The fertility of the soil should be low if using cultivars that are highly susceptible to anthracnose. Most California developed cultivars are moderately to highly susceptible to this disease (30). Anthracnose is a serious problem during June, July, and August and is favored by high soil fertility (30). Unlike salts from applied soluble fertilizer, the natural fertility of a soil cannot be readily leached with irrigation.

Special Problem: Growing a nursery on an area where fruiting strawberries were grown the same year can present problems. Crowns and roots of the previous strawberry crop may not have decomposed before fumigation, and nematodes and diseases can survive in the intact crowns and roots (48) during fumigation and infect nursery plants.

Land Preparation

The information given in the Fruit Production section is applicable for the nursery. Since the strawberry plants grow on both beds and row middles, the entire nursery area must be fumigated. Fumigation of the nursery is either completed in one operation by glueing adjacent polyethylene strips together or by treating the soil in alternate strips which involves two operations. For the latter procedure, the polyethylene mulch is removed about a week after the first fumigation and the untreated strips are then fumigated and mulched. When removing the mulch from the first fumigation, deposit the soil securing the mulch into the untreated area so that it may be treated in the next operation. All mulch needs to be removed from nursery before bed preparation.

Bed Preparation

Bed height should be no higher than required to prevent water damage to plants from flooding. On well drained soils, the wheel track may give sufficient height. With poorly drained soils, beds may need to be 4 to 5 inches high. All beds should have gentle slopes from bed center to wheel track. When selecting the bed width, consideration should be given to the density of the mother plants, transplanting date, the plant producing ability of the cultivar, desired plant size, and the equipment available. Distance between bed centers is usually 4 to 6 feet. Beds should be firmly pressed to prevent transplants from settling into bed.

Plant Spacing

Plant spacing down the row depends on the plant production capability of the cultivar, the bed spacing used, and whether the nursery is grown in the summer or winter. For the winter nursery, beds with 4 foot centers generally have a plant spacing down the row of 2 feet for prolific plant producers and 1 to 1½ feet for low and moderate plant producers (30). In the summer nursery with 4 foot bed centers, a 2 or 3 foot plant spacing may be required. Growers who use 6 foot centers require closer spacing of plants. Depending on how prolific the cultivar is, plant spacing varies from 1 to 2 feet for these wider beds. Of course, all nursery beds have only one row of plants each. As the density of the daughter plants is increased in the nursery, crown size decreases and the petiole (leaf stem) length increases (30). Since small crowns and long petioles are undesirable, a compromise must be reached by the grower between plant number and plant size.

Planting Date

The winter nursery is usually planted in January. If the weather is cool during January and February, little growth occurs, but the plants grow rapidly once the weather becomes favorable. Since the winter nursery furnishes plants for the summer nursery, late planting of the winter nursery may delay planting of the summer nursery because of small plant size and/or few plants. The summer nursery should be planted in late May or early June. Those cultivars highly susceptible to anthracnose should be set in June (30) to reduce risk of infection by the fungus.

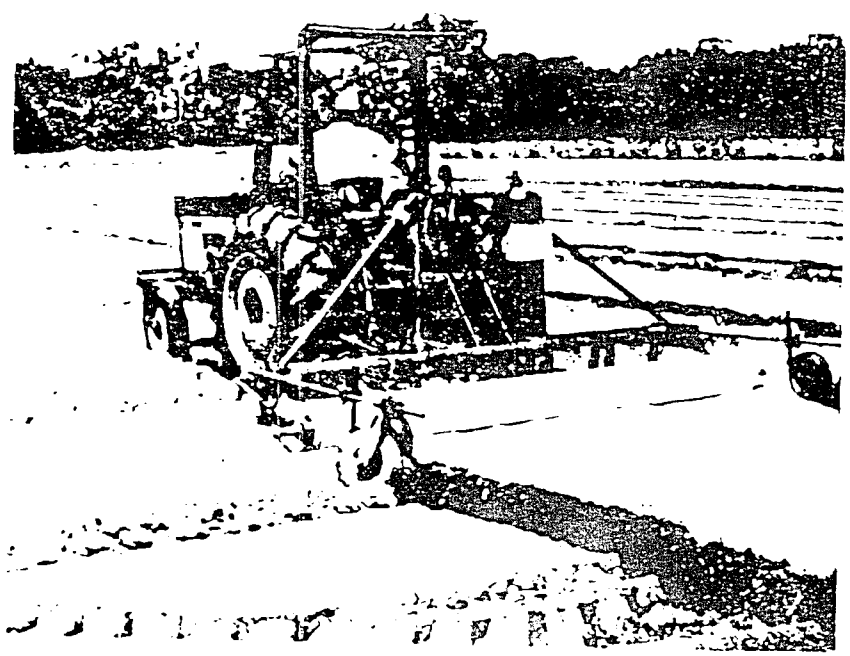

Figure 6 Fumigation is an important step in the successful production of healthy strawberry plants.

Plant Sources and Quality

Local plants should be stored in a cooler for 6 to 8 weeks before setting in the winter nursery. When placed in storage, plants must be surface-dry, packed in plastic lined containers, and stored at temperatures just above freezing (30). When set in the nursery, these plants are quite vegetative and a few flowers appear soon after planting. The removal of the flowers as soon as they appear will enhance vegetative growth (2). Plants which are dormant and held in cold storage for months (out of state plants) do well in the winter or summer nursery. Local cultivars are generally grown in winter nurseries in Florida and planted directly into summer nurseries without storage. Plants should not be removed from the fruiting field and placed in a summer nursery since these plants may be infested with nematodes, nor should a fruiting field be used for a summer nursery (30). As in the fruiting field, only high quality plants, free of disease and nematodes, and not damaged in storage or transit should be set in the nursery.

Fertilization

Follow the procedures for testing soil in the Fruit Production section under fertilization and apply phosphorus, calcium, and magnesium as required.

For the winter nursery, plants should be fertilized after plant establishment with a band of fertilizer placed about 1 inch deep and 2 to 3 inches to one side of plant row and applied at the rate of 200 lbs per acre using a 10-10-10 fertilizer. Subsequent fertilizer applications should be correlated to the level and frequency of irrigation and plant growth. Since anthracnose is not a problem until mid May, soil fertility should be maintained at a high level until that time. Apply 100 to 300 lbs per acre of a 10-0-10 fertilizer by broadcasting it over the plant bed every 2 to 3 weeks to maintain rapid plant growth and dark green foliage. More fertilizer is required in April and May than in January and February. Maintain the soluble salts level in the top six inches of the soil between 700 and 1400 ppm. Sprinkler irrigation after broadcast fertilizer application is necessary to wash fertilizer from foliage (30).

For the summer nursery, a different procedure must be used because of anthracnose (30). The nursery area needs a low initial soil fertility level. Apply the initial band of fertilizer after plant establishment as in the winter nursery. From this time until Mid-August apply only enough fertilizer to keep plants growing and with the foliage color a moderate green. **Do not permit plant foliage to become dark green and luxuriant in appearance.** Anthracnose can be a serious or even a disastrous problem under these conditions. Apply no more than 100 to 150 lbs per acre of a 10-10-10 fertilizer at each application during June to late August. After late August increase the fertilizer rate to provide rapid growth (200 to 400 lbs weekly of 10-0-10). Maintain soil soluble salt levels as in the winter nursery during May, but observe the plants closely for signs of anthracnose as long as the temperature remains above 75°F and the relative humidity is high (48).

Planting Depth and Establishing Plants

See Fruit Production section, establishing plants

Weed control

Nurseries are generally treated with a multi-purpose soil fumigant which controls many weeds (12). Some legumes are not controlled by this treatment and must be controlled by cultivation and hand weeding. Labeled herbicides may provide assistance in weed control (35). Before using a herbicide, check for plant toxicity by treating a small area. Tolerance to herbicides will vary with the herbicide used, the cultivar, the soil type, and the weather. Strawberry plants are most susceptible to damage from herbicides when newly transplanted or as young daughter plants (47).

Irrigation

Soil moisture must be maintained in the nursery at levels equal to that in the fruiting field. In addition, the soil surface must be kept moist with irrigation when the first series of runners begin to root (30). This becomes less of a problem with rooting of subsequent runners since the initial runners tend to shade the soil and keep it moist and somewhat cool. Nevertheless, special attention should be given to maintaining a moist soil surface.

Heavy summer rains often create problems of excess water. Areas of the field may flood and retard plant growth or cause plant mortality. It is important that soils have good drainage.

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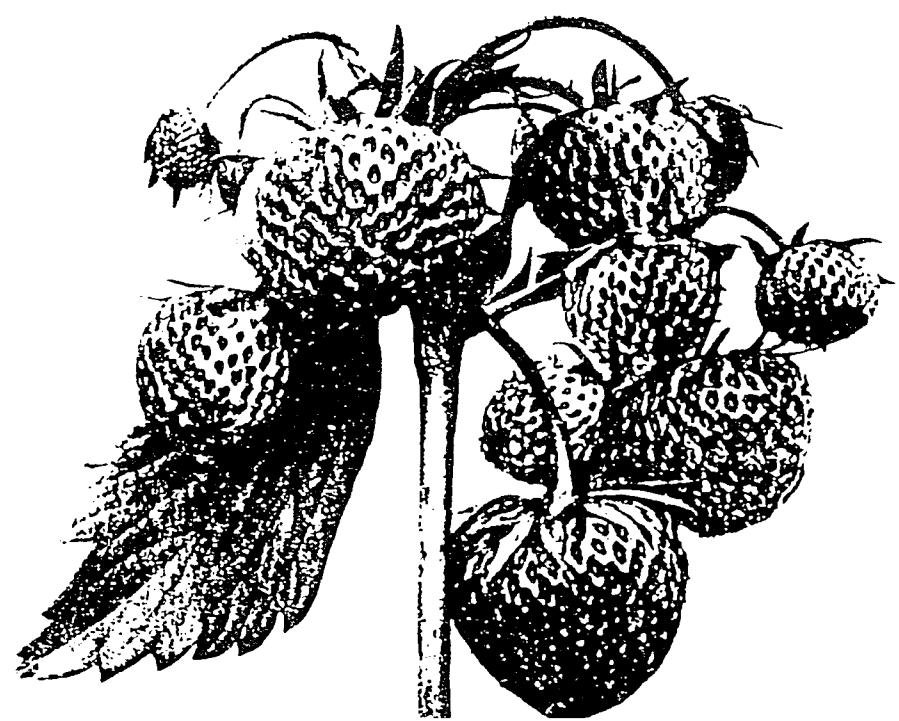
STRAWBERRIES IN THE SOUTHEASTERN AND GULF COAST STATES



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GROWING STRAWBERRIES IN THE SOUTHEASTERN AND GULF COAST STATES

By G. H. Scott, Fruit Laboratory, Plant Genetics and Germplasm Institute, *Agricultural Research Service*

Strawberry growing is an important industry in certain regions of the southeastern United States. Because of the mild climate, the plants grow almost all year. Flowerbuds are formed during the fall, winter, and spring. Ripe fruit is produced during winter and early spring. The regions covered by this bulletin are shown in figure 1.

Factors that determine a favorable strawberry-growing location are the ripening time of the fruit, transportation facilities, and available pickers. Transportation, supplies, and experienced help are usually available in areas where strawberry growing is a well-established industry.

SHIPPING SEASONS

Fruit from the South is usually marketed when there is little competition from other regions. Southern growers ship strawberries to northern markets throughout the winter and early spring. In recent

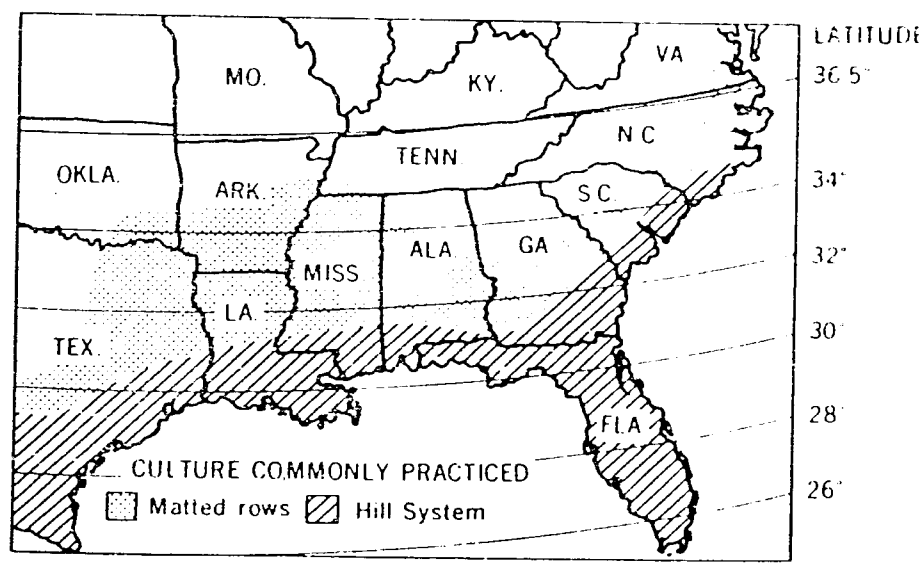

Figure 1.—The regions to which this bulletin applies are indicated by shading.

years, increased shipping by truck has replaced shipping by rail.

Figure 2 shows the strawberry production areas in the United States and the approximate ripening season in each.

Other things being equal, you should select an area where strawberries ripen at a time that markets are not well supplied from other areas. Figure 2 shows that the strawberry-ripening season in the South advances northward during late winter and spring. Shipments from each area end when berries in the next area are ripe, but a poor crop in one area may provide growers south of that area with a longer shipping season than usual.

Generally the shipping seasons along the Atlantic Coast succeed each other as described below.

The Dade County and Plant City districts in Florida are normally the only source of strawberries for markets in December and January. Shipments from these districts usually are at their height in February when the Starke-Lawtey district in north-central Florida begins to ship small quantities.

In March, shipments from the Starke-Lawtey district become heavier and those from districts farther south become lighter, unless late frosts or other weather conditions retard ripening on northern localities.

From late April to early June light shipments are made from North Carolina, Virginia, and Maryland progressing northward and shipments from Florida cease.

There are similar successions of strawberry shipments in Louisiana, Alabama, Mississippi, Texas, and other States up the Mississippi Valley.

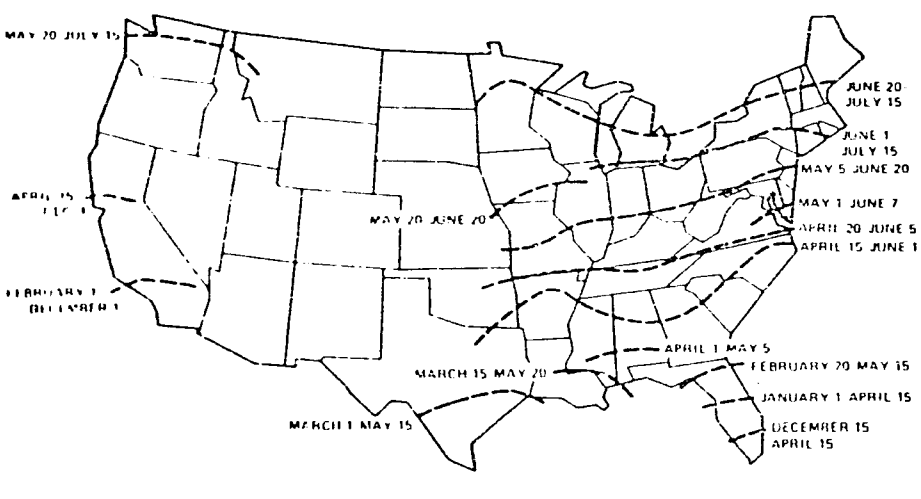

***Figure 2.*—Dates and broken lines show the approximate ripening season in the major strawberry-producing areas and the northward progression of the ripening season.**

LOCAL MARKETS

Large metropolitan and suburban areas have developed in the past 2 decades that provide substantial markets for locally grown strawberries. Pick-your-own (PYO) has become a popular method of marketing strawberries in many places. By this method, customers come to the growers' farms where they pick the berries that they buy. Growers with PYO operations are able to produce strawberries in places where commercial pickers are not available. However, they must provide field supervisors, check-out clerks, access roads to fields, space for parking cars, and be able to deal directly with customers.

SUITABLE VARIETIES

Only eight varieties of strawberries—Dabreak, Blakemore, Sunrise, Tangi, Tioga, Florida Ninety, Earlibelle, and Pocahontas—are grown extensively in the South. For a more complete discussion of strawberry varieties see Farmers' Bulletin 1043, "Strawberry Varieties in the United States."[1] Figure 3 shows where each variety is grown.

Tioga and Florida Ninety are the leading varieties grown in Florida. Tangi is the leading variety within a hundred miles of the gulf coast from western Florida to Texas, and Dabreak and Florida Ninety in the southern part of Texas; Blakemore, Sunrise, and Pocahontas are the leading varieties nothward.

The chief variety in eastern North Carolina is Albritton. Near Exmore, Va., Pocahontas has been a leading variety, but the new Apollo and Atlas varieties are being tested there as well as in all the area where the Pocahontas is grown.

GROWTH OF THE PLANT

Healthy strawberry plants set in a moist soil produce new, fine fibrous roots within a few days. For this reason, you may set them in winter, spring, or fall.

To prevent water loss when you set the plants in the spring remove all the leaves or shade newly set plants with muslin or lattice covers or spray plants frequently with water. New leaves appear almost as soon as the new roots. If the new root system is extensive, the new leaves will be large and healthy.

If, in your area, normally cool weather prevails in late fall or winter, plants should be set with all the leaves retained. Under these conditions, plants with the leaves on them will grow more than do those with the leaves taken off.

If you set plants from about March 1 to April 1, runners appear from buds in the leaf axils in 30 to 75 days and continue to appear until October or a little later. When the days shorten to about 12 hours in the fall, the growing points in the crowns of the oldest and largest plants start changing into flower buds.

Daylight periods of 12 hours or less and cool temperatures are very important in flowerbud formation.

[1] You can get a *free* copy from your county agricultural agent or from the Office of Communication, U.S. Department of Agriculture, Washington, D.C. 20250. Send your request on a post card. Include your ZIP code number.

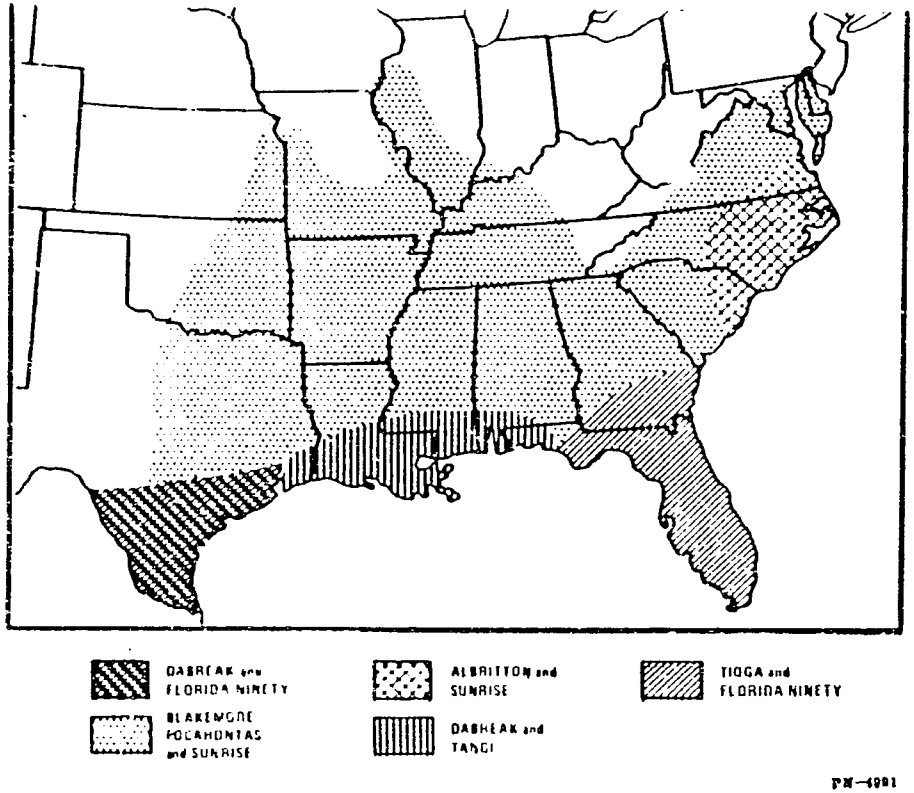

Figure 3.—Where southern strawberry varieties are grown.

Each variety may have a different day-length, cool-temperature requirement. Florida Ninety is adapted to the warmest temperatures, Headliner to slightly cooler temperatures, and Blakemore and Albritton to still cooler temperatures. Of these three, Florida Ninety can make flowerbuds under the longest day length. Headliner has a shorter and Albritton a still shorter day-length requirement.

The development of flowerbuds occurs in the oldest and strongest plants first and in the youngest and smallest plants last.

In any plant, the growing point of the terminal crown changes to a flowerbud first, followed by the growing points of lateral crowns. If the plants are growing vigorously, the change may be delayed, but the resulting flowerbuds and berries are larger than on less vigorous plants.

Records of many plants with different numbers of leaves have consistently shown that the greater the number of leaves on a plant late in the fall, the greater the number of berries it will produce.

Figure 4 shows the size of plants with 6, 10, and more than 40 leaves. Every practice should be directed toward obtaining the largest possible individual plants in the fall.

In Florida, flower clusters of Florida 90 appear shortly after the flowerbuds form because plants have practically no rest period. Farther north, the plants become partially dormant and the flower

Figure 4.—Plants with (A) 6 leaves, (B) 10 leaves, and (C) more than 40 leaves in late fall. Most fruit is produced on plants with the most leaves.

cluster do not appear until February or March. In mid-winter, if there is a period of warm weather, followed by freezing weather, the flower clusters that develop in the warm weather may be killed. However, the warm weather that causes flower clusters to grow also enables the plants to develop more flowerbuds to replace those that are killed (fig. 5).

The first flower to open on a cluster is the largest and the first flower develops into the largest fruit. The next flower develops into the second largest fruit, and later flowers develop into successively smaller fruit.

The flowers are pollinated chiefly by bees. With moderate weather, the berries mature in about 30 days after bloom. They mature slower in cool weather and faster in warm weather.

In central Florida, the flowering season may be from December 1 to the end of February, or even later in years with cool winters. In North Carolina, the flowering season is 4 to 6 weeks long.

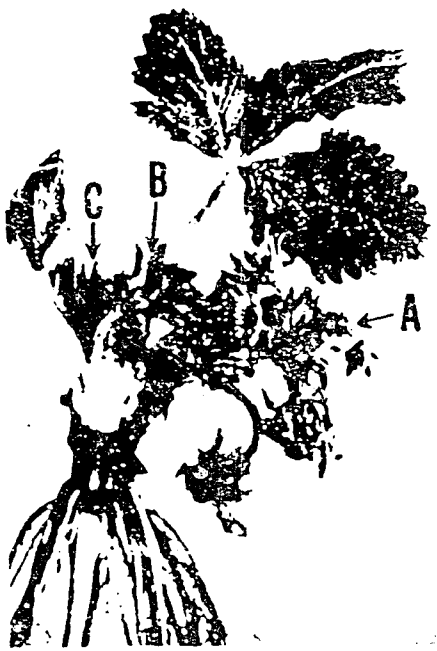

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Figure 5.—A plant with (A) the first cluster of 11 flowers and buds all killed by severe cold but with (B) a second cluster of 9 buds and (C) a third, very small cluster not killed. Weather conditions that induced winter flowering also enabled the plant to develop more flowerbuds to replace those that were killed.

SOIL

No particular type of soil is best for the varieties of strawberries grown in a given area. In Texas, coarse sandy, fine sandy, and heavy gumbo soils are used extensively; in most of Louisiana, a heavy silt loam and sandy loam, but near Hammond, La., a silt loam mixed with sand; in Florida, both heavy silt and coarse sandy loams, but near Plant City, Fla., a black sandy soil. Still other types of soil are preferred elsewhere.

In each section, the type of soil most easily managed and having the greatest content of humus (decaying vegetable matter) is generally preferred.

Drainage

Standing water in poorly drained soil seriously injures strawberry plants and may drown them or so weaken them that their growth is stunted. Soils should be prepared so that water will drain away and not stand.

Drainage is especially important because the land usually is low in strawberry-growing areas in the South. Water often stays on the ground for several days. For this reason the strawberry plants are commonly set on ridges 3 to 12 inches above the furrows that separate them as shown in figure 6. Leaf, root, and fruit diseases occur more frequently on poorly drained sites than where the drainage is good.

Preparation

Land for growing strawberries should be thoroughly prepared. It should contain abundant supplies of humus when the plants are set. You can supply the humus by applying adequate quantities of manure or by growing and turning under one or more green manure crops before the plants are set. Legumes such as crotalaria, clover, soybeans, or cowpeas, are preferred as green-manure crops.

PN-4994

Figure 6.—This field has been plowed into ridges for better drainage and has been set to single rows on the raised beds.

Use plowing methods that form suitable ridges and furnish good drainage. The height and width of the ridges depend on the character of the soil and on the slope of the field. Ridges 6 to 9 inches above the bottom of the furrows are usually adequate. The width of the ridge varies greatly in different areas. The tops of the ridges are usually leveled with a plank drag before planting. See the section entitled "Planting Systems" for further information.

OBTAINING PLANTS

Homegrown Florida stocks can be used for propagation in Florida if they are given a cold storage treatment. Plants are dug in early December, cleaned of old leaves, packed in crates lined with polyethylene film or containing damp sphagnum, and placed in cold storage at 32° to 34° F. for about 60 days.

In Florida, because of nematodes and the need for a cold rest period so the plants can produce runners, growers may obtain a limited number of plants each year from northern nurseries. These plants, set during the winter about 3 feet apart in rows about 4 feet apart, serve as mother plants for further propagation.

When cold storage plants or plants from the North are planted in the field in Florida, they are usually handled by the following schedule.

February to March.—Either col-

storage plants or new mother plants from northern sources are obtained and set. These should start growing at once.

May and June.—By this time the mother plants set from February to March should have developed enough runner plants to set a larger area of stock plants.

August.—The runner plants from the May and June setting should be ready for planting a more extended area of stock plants.

September and October.—In turn, the plants set in August should have developed large runner plants ready for planting into the fruiting fields. Florida Ninety plants should be set into the fruiting fields during the first 10 days of October.

The exact time of making the original planting and the transplanting of the runner plants varies with soil and moisture conditions. A field set in February to be used as a propagating bed is shown in figure 7.

By transplanting in May and June, it is possible to obtain enough plants to set a 4- to 5 acre area from a small original stock of 1,000 plants. Moreover, plants raised in Florida and transplanted in this manner will have large crowns. They will bear much more fruit than those brought from the North in October or November and set at once to fruit during the winter. In general, growers have found that it is unprofitable to set northern-grown plants in the fall for fruit production.

In the Louisiana strawberry area, growers propagate their plants from local stock. They also obtain nursery stocks from other states. These plants are used in propagating beds as in Figure 7. A part of the old field, which has fruited, is kept free of weeds. The runner plants from this bed are set in the autumn. The mulch in the old bed is removed and the weeds and weak plants are dug out. By November a wide bed of plants should have formed. Some growers transplant the runner plants in July and from this new bed raise plants that are set later to make the planting for fruit production.

Because nematodes are common in Louisiana, the plants should come from fields as free as possible of these pests.

In some parts of southern Texas, plants that are planted for fruit are obtained each year from northern nurseries. Growers who do this believe they get higher yields than from home-propagated plants. In other localities, plants are either propagated year after year from those locally grown or a stock is brought every few years from the North.

PN-4995

***Figure 7.*—These strawberry plants were brought from the North and set in February. By the first of June they will have made a dense mat of plants that will be used to set a larger propagating bed. The plants grown on this plot will be set on a still larger area in August, and these will produce the plants that will be set in the fruiting beds in October.**

Unless home-grown plants are free of nematodes, growers in all areas should obtain their stock from the North each year. The northern stock should be healthy and should be grown in soil free of nematodes. Florida growers have found it necessary to obtain plants from as far away as Maryland, North Carolina, Tennessee, and Arkansas.

Here are suggestions on how to get plants for districts other than Florida.

Eastern North Carolina, Alabama, Mississippi (except Bay St. Louis), and Tyler, Tex., districts.—Obtain plants in February and March from nurseries or from local fields known to be free of nematodes. Use them to set permanent fields.

Hammond, La., and Bay St. Louis, Miss., districts.—Use either of the following two methods:

(1) *January to March:* Set mother plants from the North. *June 15 to July 15:* Use the best of the runner plants produced by those set from January to March to set a larger area of stock plants. *October to December:* Use the best of the runner plants produced by those set in June and July to set the planting for fruit.

(2) *May:* Cultivate and weed out the bearing field or a part of it immediately after the picking season. *June 15 to July 15:* Use the best of the runner plants from this cleaned area to set a new planting of stock plants. *October to December:* Use the best of the runner plants from the field set in June and July to set the planting for fruit.

In the Hammond, La., area, plants set in November are usually better than plants set at other times, though plants set as late as December 20 may be satisfactory.

Houston, Tex., district.—In December to March, obtain plants from the North in sufficient quantity and set the permanent planting for fruit.

In general, planting seasons have already been indicated. Where growers use the hill system, however, there are some differences. The hill system is discussed in the next section.

PLANTING SYSTEMS

Two systems of growing strawberries are generally used in the South—the hill and the matted row. Figure 1 shows the sections in which each system is principally used.

Hill System

Under the hill system, plants are commonly set in late summer or autumn and the crop is harvested during the winter or early the following spring. Usually plants set at that time make no runners, but if any do appear, they are removed. When you use this system, you may set the plants in single, double, or triple rows (fig. 8).

Growers generally use the single row in the Hammond, La., district and in the Chadbourn, N.C., district. The plants usually are set about 1 foot apart in rows 3 feet

apart. Occasionally the rows are 40 to 42 inches apart.

In most areas of Florida and to some extent in other areas, growers prefer the double row. Where double rows are set in Florida and Louisiana, the rows on each bed are about 1 foot apart and the alleys between beds are 3 feet wide. With the spacing commonly used, wide beds on which two rows are set allow more plants to the acre than single rows do.

If the drainage is good, three and occasionally four rows are set on each bed in the lower east coast area of Florida and to some extent in Louisiana (fig. 9).

Matted-Row System

Under the matted-row system, plants are usually set in the winter or early spring. Place them 18 to 40 inches apart in rows 3½ to 4 feet apart. The runners are allowed to root. The distance between plants in the row depends on the probable danger of losing plants from drought or insects. If there is little danger, you may set the plants 40 inches or more apart and train the runner plants to form a solid mat in the spaces between plants. Where loss is likely, set the plants about 18 inches apart. Figure 10 shows grades and quantities of strawberries produced under two systems of management.

The matted-row system is commonly used in the Wallace and Chadbourn, N.C., areas; in Alabama; in all the Mississippi areas except Bay St. Louis; and in the Houston and Tyler, Tex., areas. Figure 11 shows a field grown under the matted-row system.

PN-4996

Figure 8.—Strawberry plants set in double row system with black polyethylene film as a mulch.

PN-4997

Figure 9.—Strawberry plants set in three rows on each raised bed. This plan is followed in a few areas.

Plants Per Acre

Table 1 shows the number of strawberry plants needed to set an acre when the plants are spaced according to the systems commonly used.

Table 1.—*Number of strawberry plants needed to set an acre when spaced at different distances.*

Spacing		Plants to the acre
In the row	Between rows	
Feet	*Feet*	
Double row		
1 by 1½	3	20,100
Single row		
1½	2	14,520
1	3	14,520
1	3½	12,446
1½	2½	11,616
2	3	7,260
3	3	4,840
3	4	3,630

When there is little danger of plant loss, only the number of plants specified in the table will be needed. If there is considerable danger of loss, use a somewhat larger number to insure a full stand. The experience of growers in the area will indicate the number of additional plants needed. The expense of caring for a field that has many blank spaces is out of proportion to the value of the crop. A full stand is necessary for a profitable planting.

CARE OF PLANTS BEFORE SETTING

When plants are received from the nursery, keep them cool and moist until set. If they are to be set the day they are received or the following day, place them in the shade in polyethylene bags. If they cannot

A
MATTED ROW—
30 INCHES

B
DOUBLE HILL—
EARLY

PN-4998

Figure 10.—A single picking from two rows of Blakemore strawberries to show the difference in grades and quantities produced under two systems of management. The boxes are arranged horizontally by grades: Front row, culls; second row, U.S. No. 1; third row, large; fourth row, fancy. A, three boxes containing 2 quarts of berries from a 30-inch-wide matted row (no fancy and but few large berries). B, six boxes containing 4 quarts from a double-hill row in which the plants formed early (nearly 1 quart of fancy and 1½ quarts of large berries).

be set for several days, open the bundles, separate the plants, and heel them in; or place the entire shipment in cold storage at 32° to 40° F (fig. 12).

When you set plants in the field by hand, you should not drop them far ahead of the setters, especially on dry, windy days. Whether plants are set by hand or by machine, workers should use damp sphagnum or peat to protect the plants from drying.

SETTING THE PLANTS

Set the plants by hand with one of several hand tools, or set them with a machine. A planting machine is cheapest and best for planting large areas. Regardless of the method used, two things are of special importance—setting the plants at the right depth and firming the soil well about the roots.

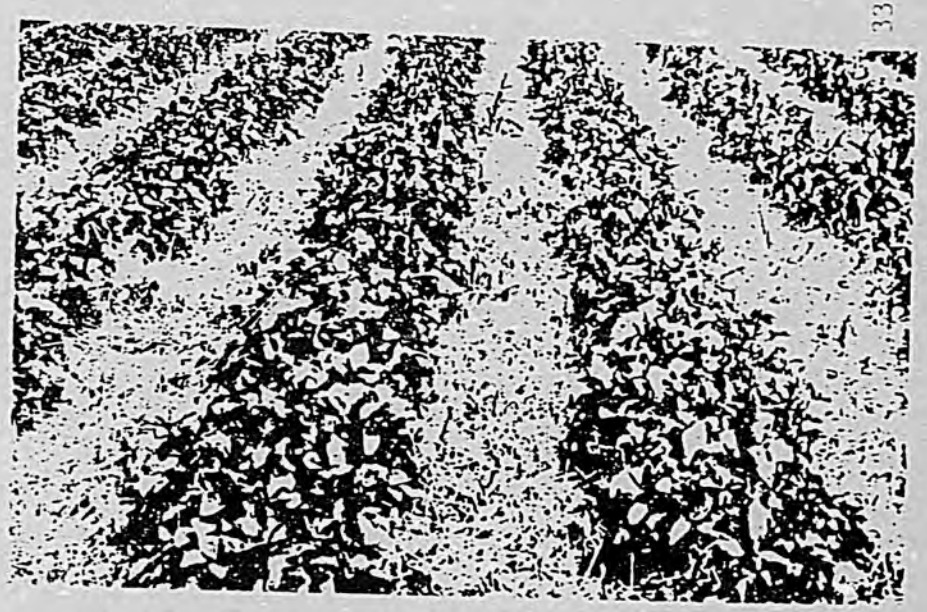
Figure 13 shows the proper depth for planting. Set the plants so the crowns are even with the surface of the ground after the soil has been packed about the roots. If the soil is not properly firmed, air gets to the roots and they are likely to dry out. The plants may produce a feeble growth or none. If the soil is thoroughly firmed, you will have little trouble keeping the plants alive.

Some growers step on the soil beside each plant after it has been set to make sure the soil has been properly firmed. When this is done make sure your foot does not injure the plant.

Setting With Machine

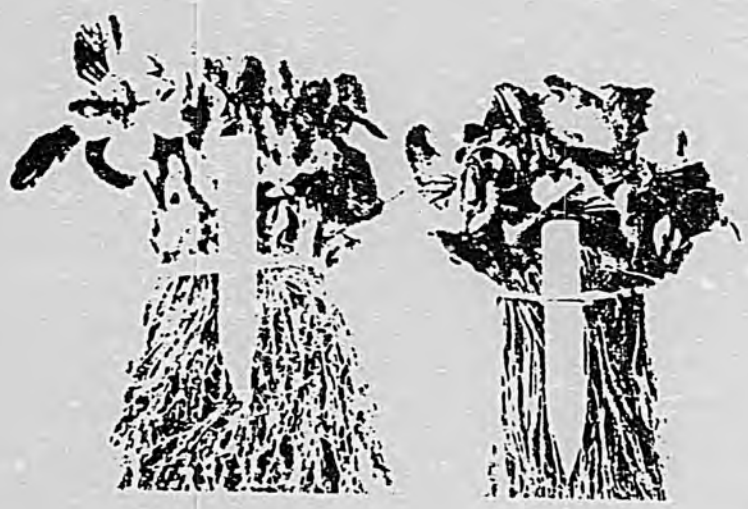
Planting machines that transplant tobacco, tomatoes, cabbage, sweetpotatoes, and other plants in trucking areas are often used to set strawberry plants on smooth land. If the soil is not moist, plants must be watered when they are set.

One man prepares the plants for the machine, another drives the machine, and two others feed plants into the machine. Experienced men can set about 25,000 to 30,000 plants a day.



PN-4977

Figure 11.—Strawberries in narrow, matted rows. They are well grown and are mulched with straw. Under this system plants are commonly set in winter or early spring 18 to 40 inches apart in rows 3½ feet apart. The runners are allowed to root and to make a narrow row.



PN-6000

Figure 12.—Plants received from the nursery are in bundles of about 25 each.

It is difficult at first to set all the plants at the right depth with the roots straight down when a planting machine is used, but with practice the droppers become expert and learn to set the plants better than by hand. A roller attached to the planter firms the soil. In large plantings on level ground, the machine may be used successfully at a comparatively low cost. This is especially true in areas where the weather is cool and moist for some time after the plants are set. In these areas, frequent irrigation is unnecessary (fig. 14).

Setting With Hand Tools

Growers with small acreages may set plants by hand, using a trowel or punch to open the soil and to press the soil back around the plants. A workman makes an opening about 6 inches deep, inserts the roots, and presses the soil back.

Two men may work together setting plants with a spade. One man inserts the spade, forces it forward, and opens a slot in the soil. The second man carries the plants and inserts them in the slots. After the roots are inserted, the first man withdraws the spade and presses the soil firmly about the roots with his foot. Plants can be set rapidly by this widely used method.

CARE OF PLANTS AFTER SETTING

Removing Flower Stems

Flower stems usually appear on winter- or spring-set plants soon after they are set. Until the plants become well established after transplanting, fruit production is a severe drain on their vitality; therefore, you should cut off the flower stems as they appear. Early-formed runner plants produce the most fruit the following year, and removal of flower stems helps to get early runners.

Care in Matted Rows

Generally, matted-row beds should not be more than 2 feet wide. Many growers find that rows 12 to 15 inches wide are better still. Berries are easy to harvest from narrow rows, and most varieties of strawberries, especially Albritton, produce better in narrow rows. If the rows are more than 2 feet wide, pickers are likely to overlook some ripe berries along the center. Unless the plants are well spaced, many berries are likely to be small.

Often it is necessary to thin plants in matted rows during the summer and autumn. To do this, roller cutters are attached to a cultivator and all runners extending into the alleys are cut off while cultivating. Surplus runners also n be removed when the field is hoed

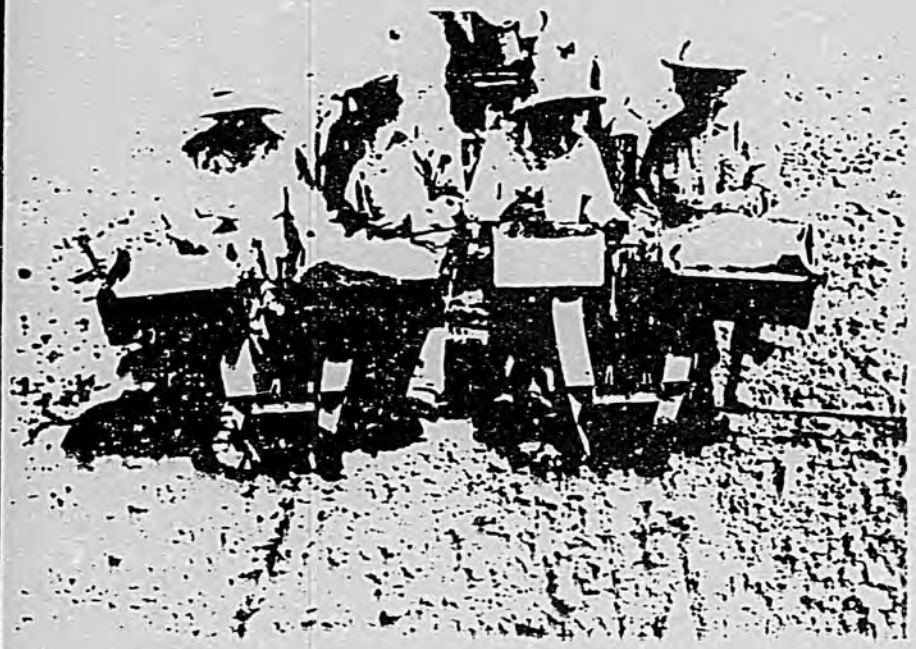
Where matted rows are 2 f wide, growers sometimes run a h tongue plow, equipped with a p 4 or 5 inches wide, down the cen of each row. This is done about first of September in first-year b or immediately after harvest in ond-year beds. This tears up center plants and cuts the row i two parts; it then might be calle double-matted row.

STRAWBERRIES AS AN INTERCROP

In some sections, growers pla strawberries as an intercrop

PN 5-

Figure 13.—Strawberry plants set at different depths: A, plant is too deep and wil be smothered. B, plant set at correct depth with the crown at the surface and th roots straight down. C, plant is set too shallow and will dry out.



PN-5002

Figure 14.—Setting strawberry plants with machines.

peach, apple, fig, orange, or other tree-fruit orchards.

When the orchard is first planted, strawberries may be set out and grown for several years before the trees need all the ground. The strawberries furnish some income from the land or at least pay the expense of caring for the orchard. The intensive cultivation given strawberries is especially good for young orchards. Because strawberries do not bear well unless moisture conditions are good, strawberries may prove a good indicator of these conditions.

TILLAGE

In the Florida and Louisiana areas, it is necessary to keep down weeds and to maintain the soil in good physical condition until time of planting. As soon as plants are set in the fruiting field, black plastic mulch is applied and no further tillage is necessary.

In areas outside of Florida, you should begin cultivation immediately after planting. Plants should be tilled each week or 10 days until late autumn or into the winter when the mulch is applied. Because tillage will keep down weeds, no hoeing is usually necessary in the spring.

New leaves grow slowly from the top of the crown, which causes the crown to grow slowly out of the ground. All new roots from the crown grow out at the base of the new leaves. Because dry air kills these new roots, it is important to hoe and cultivate moist soil toward the plants to give the new roots a chance to form.

WEED CONTROL [2]

You can easily control weeds in small home-garden plantings by cultivation and handweeding. The cost of handweeding large commercial plantings is prohibitive, however.

To control weeds economically in commercial plantings, you should consider the use of black polyethylene mulch, soil fumigants, and herbicides combined with mechanical cultivation. The combination of mechanical and chemical control depends on the general cultural practices followed by the grower.

In south Florida, growers place black polyethylene mulch over soil treated with fumigants. Strawberries are space planted through the mulch. Exposed strips of soil between the mulched rows are kept free of weeds with dinoseb spray. Apply dinoseb before flowering. Use 3 to 6 pounds per acre on soil area treated. Practically all weeds in south Florida are controlled by this method.

The rate of application of herbicides is dependent, in part, on the soil texture. Generally the lower rates of application are used on the sandy soils (light textured) and the higher rates on the clay or muck soils (heavy textured).

Many annual weed grasses and broadleaf weeds can be controlled with herbicides. Herbicides are effective against most of the more prevalent weeds including crabgrass, goosegrass, lovegrass, annual bluegrass, pigweed, knotweed, chickweed, henbit, lambsquarters, and others.

The time of application for each herbicides depends on (1) the kind of weed problem; (2) the establishment, growth, and development of strawberry plantings; (3) the varieties grown; and (4) the soil composition, climate, and cultural practices. You should get specific local recommendations for using herbicides from your county agricultural agent or State agricultural experiment station.

Apply all chemicals according to the directions on the container label. Some useful herbicides and the weeds they control are discussed here.

Chloroxuron.—Use 2 to 4 pounds. Apply as a spray on the soil in new plantings after clean cultivation when strawberry plants are well established. Apply after renovation and clean cultivation of beds in the fall. Chloroxuron kills many germinating weedgrasses and broadleaf weeds, including crabgrass, goosegrass, foxtail, chickweed, common purslane, and others.

DCPA.—Use 6 to 9 pounds. Apply as a soil treatment after transplanting or lay-by cultivation. DCPA kills germinating weed grasses and some broadleaf weeds such as chickweed, lambsquarters, purslane, and others.

Dinoseb.—Use 1.5 to 3 pounds. Apply as a spray to the soil between the rows after black polyethylene

[2] Prepared by L. L. Danielson, plant physiologist, Agricultural Environmental Quality Institute, Agricultural Research Service.

beds. Avoid drift of the spray onto the strawberry plants. Dinoseb kills germinating and small emerged weed seedlings.

Sesone.—Use 3 to 4 pounds. Apply as a soil treatment 2 weeks after transplanting and after clean cultivation following harvest. Sesone kills germinating annual broadleaf weed seed including henbit, knotweed, lambsquarters, pigweed, and some other germinating weed grasses.

MULCHING

Most growers use a mulch in strawberry fields in the South. The principal uses of a mulch are to keep the berries clean, to prevent decay, to conserve moisture, to protect the flowers from frost, and to keep down weeds.

Mulching materials most commonly used in the South are black plastic; pine needles or wild hay; or wheat, rye, or oat straw. All of these mulches are satisfactory.

All commercial acreages in Florida and Louisiana are mulched with black plastic. The plastic mulch is applied when the plants are set or soon after they are set in the plantings for fruit.

Use plastic that is 1 to 1.5 millimeters thick and wide enough to cover the top and sides of the beds. You can apply the plastic just prior to planting and set the plants through the plastic, or you can lay the plastic over the plants after planting and pull the plant tops through slits in the plastic.

When you use pine needles as a mulch, rake them during the winter and stack them along one or both [illegible] of the beds until it is time to spread them around the plants. Hay and straw mulches are raked and stacked in summer and fall.

Apply organic mulches just before the blossoms open. Distribute the mulch along the rows from a truck and place it around the plants by hand as shown in figure 15. After the mulch has settled, it should be 1 to 3 inches deep.

PREVENTING FROST INJURY

In nearly all parts of the South, frost causes more loss than in most other strawberry growing regions. Loss of an average of six or seven flowers per plant is not unusual in spaced plantings. Normally, the first flowers to open develop into the largest berries. If you lose six flowers per plant, this represents a loss of 4,000 to 5,000 quarts per acre of the best and earliest berries in a better-than-average field. Losses in matted-row fields probably are less than in spaced plantings because yields in matted rows are smaller.

PN-5003

Figure 15.—**In mulching, straw or wild hay is distributed along the rows from a truck, spread by fork, and placed around the plants by hand.**

Growers usually prevent frost injury by covering the plants with a mulch and by spray irrigation. A light covering of mulch will protect against most frosts. In cool weather, the flowers can be pollinated over a period of several days so you can leave the plants covered 2 or 3 days if frosts are expected on successive nights.

Spray irrigation applied through rotating sprinkler heads is especially effective in preventing frost injury. You can use nozzles with small openings because it takes less water than ordinary irrigation. Start the spray when the temperature drops to 32° F. and continue it until all ice has melted and the temperature is above 32°. Apply the water at a rate of about one-tenth inch per hour. This method of frost control has rapidly increased with irrigation of strawberries (figs. 16 and 17).

Large power-driven fans are sometimes used for frost protection in low areas. This method of protection is worth considering where conditions are favorable. Oil heaters are effective under some conditions. Growers who think they could use either of these methods should get advice from their county agricultural agent or State agricultural experiment station.

USE OF LIME

In a strawberry field, lime may be useful in several ways. It is a source of calcium, and in the form of dolomite, is a source of magnesium as well. Lime also lessens the acidity of the soil.

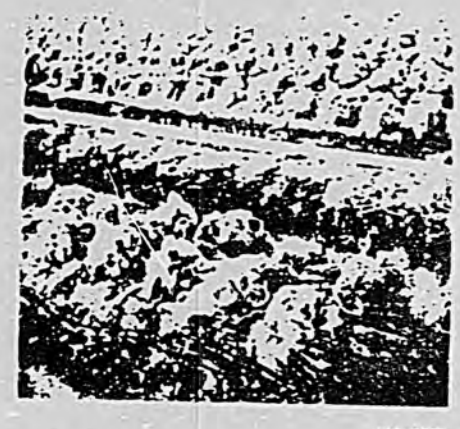
PN-5004

Figure 16.—**Sprinkler irrigation of strawberry plants for frost protection at blossom time. Note ice on plants.**

Strawberries usually grow well on light soils where the acidity measures pH 5.5 to 6.5. They may grow well where acidity measures pH 5.0 to 7.0 if there is a great deal of organic matter in the soil.

Where soil acidity is pH 4.5 to 5.3, lime is needed. You should apply 1,000 pounds per acre on light soils to 2,000 pounds per acre on heavy soils. Where the soil is less than pH 4.5, apply 1,500 pounds on light soils to 3,000 pounds on heavy soils.

Lime ties up free aluminum, which is toxic to strawberry plants, and makes calcium and magnesium available. It may also help the tilth of the soil. Apply lime with care because too much will dwarf the plants and reduce the size of the berries. It is best to disk lime into the soil a year or two before the strawberries are planted.



FN-5605

Figure 17.—Ice on strawberry plants for protection of blossoms from frost. Planting in Louisiana mulched with black polyethylene plastic.

USE OF FERTILIZERS

The principles that apply to the use of fertilizers on other crops generally apply to their use on strawberry fields. Because of differences in soil, the use of fertilizers is chiefly a local problem that each grower must solve.

Nitrogen usually is the most important element in fertilizers applied to strawberries. You may profitably apply nitrogen from early September until December or January.

Because the availability of nitrogen in different fertilizers varies, the source of the nitrogen is important. Nitrogen from mineral sources such as sulfate of ammonia and nitrate of soda is quickly available, but nitrogen from organic sources such as cottonseed meal, tankage, or fishmeal acts more slowly.

Sulfate of ammonia tends to make the soil more acid and should not be used if soil acidity is pH 5.5 or lower. Insufficient nitrogen in the soil results in small crops. Too much nitrogen may result in dense foliage. The dense foliage and shade may make the fruit more likely to rot. Either too little or too much nitrogen may cause the berries to mature late.

On mineral soils in Florida, use 1,400 to 1,800 pounds of 6-8-8 fertilizer per acre or an equivalent amount in other grades. The amount you use depends on whether or not you irrigate. Apply the higher amount when you irrigate and the lesser amount when you do not. Half of the fertilizer should be broadcast and disked into the soil prior to bedding. Apply the other half in a single narrow band in the planting space at time of bedding.

For marl and rock soil, use 1,200 to 1,300 pounds of 6-12-12 per acre, half broadcast before bedding and half banded at time of bedding. If plastic mulch is not applied until 2 to 4 weeks after planting, an additional band of 300 pounds of 5-10-5 per acre may be needed at time of bedding.

In Louisiana, 800 to 1,000 pounds of 5-10-10 per acre is recommended. If you do not use an organic mulch, place the fertilizer 6 to 8 inches deep directly under the area where the plants will be set and then prepare the beds. When you use an organic mulch, apply half of the fertilizer before planting and the other half in January when you mulch the plants. When you propagate nursery plants, do not fertilize them when you set the plant beds; apply 200 to 300 pounds of 5-10-10 per acre on the beds beside the plants in early September and the same amount again in mid-October.

On the North Carolina coastal plain and similar areas, nitrogen is more important than other fertilizers. On new plantings, broadcast 800 to 1,000 pounds of 8-8-8 per acre and work it into the soil at least 10 days before planting. Follow this a month after planting with 30 pounds of nitrogen per acre on the beds, and in late August or September, apply 40 to 50 pounds more nitrogen per acre.

On light, sandy soils only, apply 30 pounds of nitrogen per acre to new plantings from mid-January to early February. If you apply nitrogen at this time on silt-loam soils, it may cause too much growth and soft berries.

On old plantings being renovated, apply 30 pounds of nitrogen per acre on the beds immediately after harvest, and then follow this with 40 to 50 pounds per acre in August or September.

IRRIGATION

Growers generally need to irrigate strawberries because droughts occur often during the long growing season. Serious losses may result. More than 80 percent of growers in Florida and most of the growers in Louisiana use some type of irrigation. Spray irrigation is used most often in Florida and surface irrigation is used in Louisiana and Texas (figs. 18 and 19).

Water for surface, or alley, irrigation is usually obtained from artesian wells in the Hammond, La., area and is pumped from bayous, streams, and lakes in the Houston, Tex., area. In Florida, growers get water from wells, lakes, and streams. A flowing artesian well provides a continuous water supply. After the well is bored, the only cost is distributing the water.

When drought occurs in summer, growers irrigate to save the propagating beds. They often irrigate to moisten the soil for setting the plants but more frequently to counteract drought during the fruiting season.

In surface irrigation, the alleys should have a slight slope and should be free from obstacles when you apply the water. Water runs down the alleys without waterlogging the soil if the rows are not more than 500 feet long.

During the planting and picking seasons, run the water down every other alley. Workers can walk in the unirrigated alleys. Then water the unirrigated alleys at the time of the next irrigation. If the soil is in suitable condition for working, cultivate the irrigated alleys about 2 days after each irrigation.

RENOVATION

Growers seldom renew a planting under the hill system. It is too costly. They plow it up at the end of the first fruiting season. Under the matted-row system, on the other hand, the cost of renovation is usually less than the cost of setting and caring for a new planting. Where the matted-row system is used, fields are kept 2 to 4 years or as long as they produce profitably.

The length of time a planting remains profitable depends on the natural fertility of the soil and on

PN 5006

Figure 18.—Irrigating strawberries during the picking season. Water is run down every other alley. Alternate alleys are left dry for pickers.

the prevalence of diseases, insects, or weeds. If plants are badly infested by these pests, you should not renew the old planting. Set a new planting.

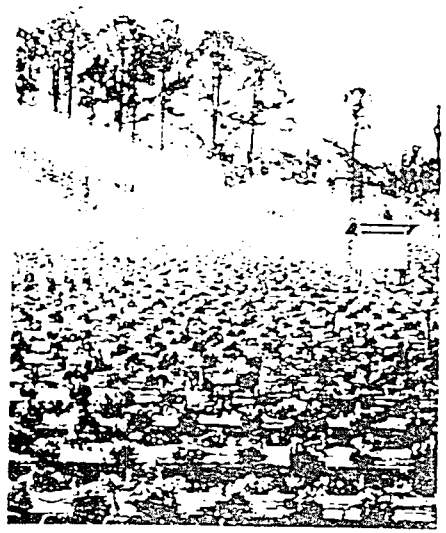
If you turn under green-manure crops before you set the planting and if the soil is in good condition, you may harvest two or more crops before you plow up the planting and set a new one. If a field becomes weedy, it may not be worth renewing. Local conditions largely govern the length of time a field is profitable.

When a planting is to be renewed, first cut the tops with a mowing machine. Then the foliage and mulch should generally be turned under or rototilled into the soil. This will improve the texture of the soil. If the mulch is very heavy, you may remove part of it before plowing.

In all sections where renewing is done try to obtain large, vigorous plants by October when fruit-bud formation begins in much of the South.

Large plants develop in matted rows if you space the plants 8 to 10 inches apart. The amount of thinning necessary depends on the variety and to some extent on the season and the soil.

You may thin the plants by running a spike tooth harrow or cultivator once or twice across the rows, and once down the rows. This tears up the weaker plants. Use a hoe to further thin the plants if they are still too thick. Under favorable conditions, the plants will develop new foliage within 2 or 3 weeks, and the field will have the appearance of a new planting.



PN 5007

Figure 19.—Irrigation of strawberry plants in the hill system. Plants are mulched with black polyethylene.

HARVESTING

Strawberries must be handled with great care if they are to reach the market in the best condition. Berries should be picked at least every other day. At the height of the season, it may be necessary to pick berries daily. Do not leave any ripe berries in the field because at the next picking, they will be too soft to ship.

One soft berry in a basket may spoil the entire contents, and one spoiled basket of berries may spoil the looks of a crate by the time it reaches market. The growth habit of the foliage and the differences in growth of different varieties make it more difficult to pick clean in some sections than in others. Dense foliage may hide the berries; therefore, an open growth is more desirable.

Pinch off the stem of each berry when it is picked, and leave about a half inch of stem attached to each berry. Place the berries carefully in the basket; do not throw or drop them. Never leave baskets of berries in the sun, but take them to the packing shed or place them in the shade as soon as possible after picking.

Pickers are paid by the quart. The amount paid varies with the area, with the grade of work done, and with the management plan. Growers may pay the best pickers more than they pay untrained and poor pickers. The extra pay encourages careful work, and the berries are worth more when handled by careful pickers (fig. 20).

The number of pickers to the acre varies greatly. At the height of the season, eight to 10 pickers per acre are sometimes needed in the best fields. On a field yielding an average crop of five hundred 12-pint crates to the acre, five pickers working every day should take care of the crop.

In most areas in the southeastern United States, pickers use wooden or metal carriers that hold 6 quart. The carrier shown in figure 21 is cheaply constructed and very convenient.

In a field that is tended carefully, there should be very few berries that are not of the best market grade. Some fields have almost perfect berries, and no sorting is necessary after picking. The best crops are obtained by spacing the plants properly in the row and weeding the field thoroughly. There must be sufficient mulch and humus in the soil to

PN-5008

Figure 20.—Harvesting strawberries from the hill system in Florida with the aid of a machine to transport the pickers.

maintain an adequate supply of moisture while the berries are growing and ripening.

DISEASES[3]

Several diseases attack strawberries at all stages of development from the time plants are set in the nursery beds until fruit is harvested. You can control some diseases by careful selection of planting stock and other diseases by spraying with fungicides. Certain diseases, however, cannot be controlled once they get in a planting.

Try to prevent diseases if possible. Some measures that you can take to prevent and control diseases in strawberries follow—

- Use only plants that are as free of disease as possible; use State-certified plants when available.
- Practice rotation with other crops; do not plant strawberries after strawberries or tomatoes.

PN-5009

Figure 21.—Six-basket carrier commonly used in picking strawberries.

[3] Prepared by J. R. McGrew, plant pathologist, Fruit Laboratory, Plant Genetics and Germplasm Institute, Agricultural Research Service.

- When diseases are present, spray plants with fungicides in the fall and spring to control leaf diseases, and in spring as soon as flowerbuds appear to control fruit rots.

Some useful fungicides for the control of fruit and leaf diseases are discussed below. Dosages are in pounds of active ingredients per acre. Follow the directions on the container label for each product.

Benomyl.—Use ½ to 1 pound. Use from bloom to harvest for fruit rot control. Should be used alternately with another fungicide for Botrytis rot control.

Bordeaux mixture.—Use 0.75 to 2.5 pounds (as metallic copper). It is generally used only after harvest.

Captan.—Use 1 to 4 pounds. It can be used anytime.

Dichlone.—Use 0.2 to 0.4 pound. Do not use within 3 days of harvest.

Dyrene.[4]—Use 1 to 3 pounds. Do not use within 5 days of harvest.

Ferbam.—Use 1 to 3 pounds. Do not use within 14 days of harvest.

Thiram.—Use 1.25 to 3.25 pounds. If applied within 3 days of harvest, wash off residue.

Zineb.—Use 1 to 3.5 pounds. Do not use within 7 days of harvest.

Those diseases that are especially destructive in the South are discussed in the following sections. For a more complete discussion of strawberry diseases see Farmers' Bulletin 2140, "Strawberry Diseases."[5]

[4] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

Fruit Rots

Several fungi cause green and ripe berries to rot. The most common one is gray mold (botrytis rot).

Besides spraying, a grower can do several things to reduce the amount of rot in a planting. Keep plants well spaced. Do not use nitrogen fertilizer just before harvest. Use a mulch to keep the fruit off the soil and a mulch or sprinkler to protect green fruit from spring frosts that lead to rot.

Fungicide sprays applied at weekly intervals from the time flowerbuds first appear in the spring frequently save enough berries from rot to more than pay for the material and labor. The materials most often recommended are captan or thiram.

Leaf Diseases

Leaf spot, leaf scorch, and blight are common strawberry diseases. Under cool, wet conditions in fall and spring, they may destroy enough leaves to weaken the plants and reduce the size of the crop. Varieties differ in their susceptibility to these diseases (fig. 22).

Should any of these diseases appear in a planting, generally good protection is provided by two or three fungicide sprays in the spring at 1- to 2-week intervals before harvest and one or two sprays in the fall at 3- to 4-week intervals. Any

[5] See footnote 1 on page 3.

PN-6010

Figure 22.—A, leaf spot infection on upper side of leaves; spots have purple edges with white centers. B, leaf scorch on upper side of leaves; spots are dark purple.

of the materials listed in this section are satisfactory to use.

Root Diseases

Black root rot may be caused by one or a combination of unfavorable cultural conditions, fungi, or nematodes. Plants that have black root rot lack vigor and productivity.

Causes of black root rot are so variable that no recommendations to prevent it can be made here. Your local county agent or State agricultural college may be able to suggest control measures for your area.

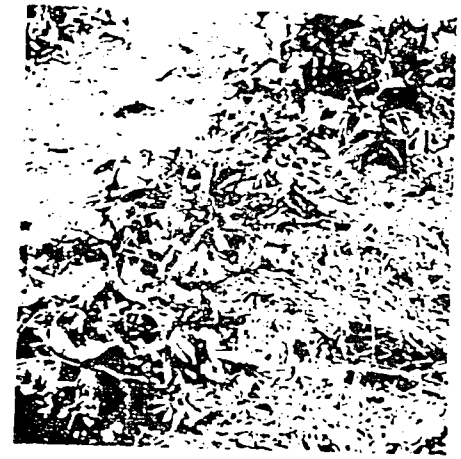
Red stele root rot and verticillium wilt are uncommon in the areas covered by this bulletin. Both are more common in cooler climates. Plants with these diseases may wilt and die. Red stele is more severe in wet than dry soils and verticillium wilt is more severe when strawberries follow tomatoes or potatoes in crop rotation.

Crown Diseases

Anthracnose, or crown rot, affects runners and crowns and is most serious in hot, wet climates. Symptoms are black lesions on runners and crowns. When crowns are affected, sudden wilting may occur. Frequently, patches of plants are killed (fig. 23).

This disease organism does not live-over in the soil so the best control measure is to use nursery plants free of the disease. Do not use plants from fields that are infected or that border infected fields. *Benomyl* at 1 pound per gallons of water applied every 2 weeks from time of planting in the nursery until plants are set in the fruiting field protects nursery plants.

Rhizoctonia bud rot is most common in hot, moist climates. The fungus lives in the soil and may kill young buds. Unhealthy, reddish side buds may grow from affected



PN-5011

Figure 23.—Strawberry plants killed by anthracnose crown infection.

plants. A severe case of rhizoctonia bud rot may result from cultivation that throws soil on the crowns of the plants.

Virus Diseases

The two general types of viruses that affect strawberries are killer viruses and latent viruses. Killer viruses such as aster yellows produce severe symptoms and kill out individuals mother plants along with the attached runner plants. But, generally, very few plants are affected and the overall damage does not warrant control measures. The latent viruses, on the other hand, are frequently responsible for the progressive weakening of a planting stock.

A latent virus by itself may produce no obvious symptoms in a strawberry plant. But combinations of two or more may produce yellow leaves, crinkled foliage, or severe stunting of plants. A single virus may limit the number of runner plants that form and result in low yield and small, dull berries. The only practical thing you can do is replace the planting stock with certified virus-free plants.

When you set out a field of virus-free plants, you should put the new planting more than 1,000 feet from older planting of strawberries because viruses come only from other strawberries. The spread of viruses in the South by aphids is so limited that the use of insecticides to control aphids is probably not warranted.

NEMATODES[4]

Strawberries are attacked by several kinds of nematodes but the most damaging ones in the South are the root-knot (*Meloidogyne* sp.), bud and leaf (*Aphelenchoides* spp.), lesion (*Pratylenchus* spp.), and sting (*Belonolaimus* spp.) nematodes. Other nematodes such as stubby-root (*Trichodorus* spp.), ring (*Criconemoides* spp.), lance (*Hoplolaimus* spp.), and dagger (*Xiphinema* spp.) occur frequently but usually cause little damage.

All soil-inhabiting nematodes can be controlled by fumigating the soil with nematicides. Nematodes in roots, leaves, and buds can be killed by the hot-water treatment of plants; immerse the plants in water at 127° F. for 2 to 5 minutes before transplanting. Hot water treatment may cause an initial set back in plant growth during the first year in the field.

[4] Prepared by R. V. Rebois, nemotologist, Plant Protection Institute, Agricultural Research Service.

All of the nematicides can be used to treat the soil before strawberries are planted. Dibromo chloropropane is the only federally registered nematicide that can be used either before or after planting. However, control is more effective when treatments are used before planting. In general, successful fumigation consists of careful preparation of the soil and application of the correct amount of nematicide at the proper soil depth (fig. 24).

Nematodes, diseases, and weeds can be controlled by treating the soil with methyl bromide, sodium methyldithiocarbamate, chloropicrin, or a mixture of DD and methylisothiocyanate. Equally as good, but suggested for nematodes only, are materials containing dichloropropenes, ethylene dibromide, or dibromochloropropane.

Chloropicrin.—Use 480 to 635 pounds as an overall treatment. Leave in the soil 24 to 48 hours undisturbed. Aerate the soil by cultivating 7 to 14 days before planting.

Dichloropropene (DD, 1,3-D).—Use 230 to 320 pounds as an overall treatment. Leave in the soil 7 days before planting for each 100 pounds of dichloropropene applied. Leave in the soil a week longer in case of heavy rains or if the soil temperature is below 60° F.

PN-5012

Figure 24.—Effect of fumigation of the soil on the growth of strawberry plants: Left, fumigated; right, not fumigated.

Dichloropropene and methylisothiocyanate mixture (DD-MENCS).—Use 145 to 240 pounds as an overall treatment. Leave in the soil undisturbed for 4 to 7 days when the soil temperature is 60° F. or higher and 7 to 21 days at lower temperatures. A plastic tarp or a water seal of 0.5 to 1 inch of water may be used to increase the effectiveness of the treatment. Aerate the soil by cultivating or disking after the exposure period. After aeration, wait 7 days for each 115 pounds used before planting.

Ethylene dibromide (EDB).—Use 90 to 108 pounds as an overall treatment. Leave in the soil undisturbed for 14 to 21 days before planting or 1 week longer in unusually wet periods.

Dibromo-chloropropane (DBCP).—Use 17.6 to 26 pounds before planting as an overall treatment or 8 to 26 pounds before or after planting as a row treatment. Use on mineral soils only. Do not exceed maximum dosage per acre in a single year. No waiting period is required before planting.

Methyl bromide (MBR).—Use 240 to 435 pounds as an overall treatment. Put a plastic tarp over the soil after treatment and leave it in place for 48 hours. Do not plant for 3 to 7 days after the tarp is removed, or 10 to 14 days longer on heavy or organic soils. Cultivate wet or heavy soils before planting.

Sodium methyldithiocarbamate (SMDC).—Use 124 to 338 pounds as an overall treatment. Irrigate the soil after the nematicide is applied. A water seal of 0.5 to 1 inch of water or a plastic tarp may be placed over the soil after irrigation. Do not disturb the soil for 5 to 7 days; then aerate by cultivating. Do not plant for 7 to 14 days after aerating the soil.

To some degree, all nematodes reduce fruit yield, damage plants and root systems, and cause poor stands and inefficient use of fertilizer and water. Root-feeding nematodes increase the severity of several plant diseases caused by viruses, fungi, and bacteria.

Root-Knot Nematodes

Northern root-knot nematodes (*Meloidogyne hapla*) are the only root-knot nematodes that attack strawberries (fig. 25). These nematodes cause small knots on the roots of plants. The knots range from less than one-eighth inch up to one-fourth inch in diameter. Frequently there are several short branch roots above each knot.

In older infections, the knots begin to decay, the root system is greatly reduced, and the roots often appear matted. Plants are stunted, leaves are yellow, and few runner plants are produced. Infections often appear as patches in a field of otherwise healthy appearing plants.

Crop rotation with corn, small grains, grasses, cotton, hairy indigo, and crotalaria will aid in controlling these nematodes. Nematicides also are effective.

Bud and Leaf Nematodes

The strawberry bud nematode (*Aphelenchoides fragariae*) causes the bud disease known as spring

PN-5013

Figure 25.—Roots of a strawberry plant showing galls caused by root-knot nematodes.

crimp, or red plant. Another bud nematode (*Aphelenchoides besseyi*) causes a similar disease known as summer crimp, or summer dwarf, which usually occurs farther south than spring crimp.

These nematodes enter the developing buds from the soil early in the growing season, and symptoms usually appear at the beginning of warm weather. Plants are dwarfed and leaves are small, narrow, crinkled, and dark colored or reddish (fig. 26). Many severely damaged plants die, and less severely damaged plants produce low yields of inferior quality fruit.

Bud nematodes usually live among the developing leaves and buds and feed on the leaf surfaces. During cold weather their numbers decreases, but some remain alive. They can withstand extreme drought and remain alive in the soil.

Symptoms of nematodes injury usually appear from July to October. Except in Florida, symptoms disappear during the winter.

All infected plants and connected runner plants is propagating beds and nursery fields should be discarded. Bud nematodes often are washed out of infected plants by rains and irrigation and carried to healthy plants. You can reduce the numbers of these nematodes, but not eliminate them, if you do not plant strawberries in infected fields for 1 or 2 years.

Lesion Nematodes

At least three species of lesion nematodes attack strawberries. They are common in most fields but damage is frequently unrecognized. They attack the roots and initially cause small, round or elongated spots that are amber to dark brown in color. In older infections, root decay is extensive and is hard to distinguish from that caused by root-rot disease.

Infected plants are stunted and appear in patches in the field. Leaf-stalk lengths are shortened, leaves may become slightly yellow, and emerging leaves on the most severely infected plants appear bluish. Lesion nematodes increase verticillium wilt in many areas.

Lesion nematodes are hard to control by crop rotation because most

PN-5014

Figure 26.—Left, plant affected with summer dwarf; right, healthy plant.

cultivated crops are good hosts and sustain or increase the numbers of these nematodes. Oats are the best of the small grains in reducing infestations, but grass sods are more effective than any of the crops. Do not grow strawberries after beans or peas of any kind, nor after legume cover crops such as alfalfa, lespedeza, vetch, or winter peas.

When northern and peanut root-knot nematodes are not a problem, growing peanuts once every 3 or 4 years will help reduce the numbers of lesion nematodes in the soil if the peanuts are harvested. Harvesting the peanuts removes large numbers of lesion nematodes from the field because these nematodes enter the shells of peanuts more than they do the roots. Lesion nematodes are easily controlled with any of the nematicides listed in this section.

Sting Nematodes

Sting nematodes (*Belonolaimus longicaudatus*) are more destructive to strawberries than any other kind of nematodes, but they are found only in the light, sandy soils of the lower coastal plains. They are most common in Florida where they cause high yield losses.

These nematodes are larger parasites that live in the soil and feed on roots. They especially damage the growing tips of developing roots. In light infestations, long stringy main roots develop with no small feeder roots. In heavy infestations, most developing roots are perma-

nently damaged and plants have a very limited root system that is best described as stubby-root.

Infected roots have brown spots on them or they become entirely brown, and root tips may be slightly swollen. Plants become stunted and weak, leaf margins turn brown, and some plants may die.

Sting nematodes are hard to control by crop rotation because most crop plants are good hosts and sustain or increase the numbers of these nematodes. In most areas sting nematodes can be controlled by growing peanuts, except in Virginia and North Carolina, where a different kind of sting nematode occurs. Hairy indigo, tobacco, crotalaria, and marigolds help reduce the numbers of sting nematodes. These nematodes are easly controlled with nematicides.

Most grasses, small grains, corn, or cotton should not be grown where sting nematodes are a serious pest.

INSECTS

Many kinds of insects damage strawberries by feeding on the plants or by transmitting virus diseases. Insecticides can be used to control most insects.

Aphids are controlled with endosulfan, strawberry weevils with methoxychlor and spider mites with dicofol. Field crickets and white grubs may no longer be controlled with chlordane since its use has been suspended by EPA. Contact your appropriate Cooperative Extension Service, State Agricultural Experiment Station, or County Extension Agent for information applicable to your locality. Follow the directions and heed all precautions on the container label.

For a more complete discussion of insect pests of strawberries, see Farmers' Bulletin 2184, "Strawberry Insects—How to Control Them."[1]

USE OF PESTICIDES

This publication is intended for nationwide distribution. Pesticides are registered by the Environmental Protection Agency (EPA) for countrywide use unless otherwise indicated on the label.

The use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This Act is administered by EPA. According to the provisions of the Act "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12(a)(2)(G))

EPA has interpreted this Section of the Act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State Agricultural Experiment Stations, or County Extension Agents for information applicable to their localities.

The pesticides mentioned in this publication are available in several different formulations that contain varying amounts of active ingredient. Because of this difference in active ingredient the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated in the publication. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound of active ingredient equals 2 pounds of a 50% formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers on all pesticide containers. Use only pesticides that carry one of these registration numbers.

USDA publications that contain suggestions for the use of pesticides are normally revised at 2 year intervals. If your copy is more than 2 years old, contact your Cooperative Extension Service to determine the latest pesticide recommendations.

The pesticides mentioned in this publication were Federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

[1] See footnote 1 on page 3.

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Strawberry Production in California

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Strawberry Production in California

Introduction

California strawberry acreage increased rapidly following World War II to reach a peak of 20,700 acres in 1957. By 1966, acreage dropped to 7,800 acres and remained about 8,000 acres until 1973. In 1980, 11,000 acres produced 512,500,000 pounds of strawberries with approximately 70 percent sold fresh and 30 percent processed. Average production was 23.3 tons per acre (see fig. 1).

The coastal areas of California produce 95 percent of California's strawberries. About one-half of the acreage is in the south coastal California counties of Orange, Ventura, San Diego, and Los Angeles; the remainder is in the central coastal counties of Monterey, Santa Cruz, Santa Clara, Santa Barbara, and San Luis Obispo, plus a very few areas in Fresno County (see table 1).

During the past 10 years acreage has increased 30 percent, but total production has increased 77 percent and the dollar value of the crop has increased 323 percent. New varieties and improved cultural practices have increased production. Improved fruit quality, longer harvesting seasons, and better post-harvest handling—coupled with effective advertising and promotion—have helped to market the increased volume of berries successfully. (For further details on the economics of the California strawberry industry, see table 2.)

This publication describes the cultivars and production procedures currently recommended for strawberry culture in California.

TABLE 1. Strawberry Acreage by Major Areas, 1975–1981

	1975	1976	1977	1978	1979	1980	1981
Southern California							
Oxnard	2,100	2,320	2,340	3,290	2,600	2,500	2,420
Orange-Los Angeles	1,900	2,160	2,810	2,640	2,180	2,060	2,270
San Diego and others	670	640	640	760	870	890	880
Total	**4,670**	**5,120**	**5,790**	**6,690**	**5,650**	**5,450**	**5,570**
Northern California							
San Jose-Watsonville-Salinas	4,210	4,550	4,590	5,050	4,630	4,240	4,210
Santa Maria	820	860	870	910	910	1,100	960
Fresno and others	300	270	350	240	310	210	160
Total	**5,330**	**5,680**	**5,810**	**6,210**	**5,850**	**5,550**	**5,330**
Total California	**10,000**	**10,800**	**11,600**	**12,900**	**11,500**	**11,000**	**10,900**

TABLE 2. Utilization and Dollar Value of California Strawberries

Year	Fresh		Processed		Total Value
	Tons	Percent total	Tons	Percent total	
1951	27,150	62	16,900	38	$ 18,329,000
1955	32,200	39	51,150	61	33,627,000
1960	42,900	54	35,500	46	32,504,000
1965	53,750	60	35,500	30	39,949,000
1970	107,700	75	36,800	25	62,311,000
1971	117,500	76	34,000	24	70,385,000
1972	113,200	80	29,150	20	67,564,000
1973	113,350	71	46,650	29	83,830,000
1974	138,800	73	52,550	27	104,456,000
1975	134,000	71	54,500	29	111,216,000
1976	141,500	67	70,000	33	135,809,000
1977	171,500	66	89,200	34	168,362,000
1978	185,650	74	64,950	26	144,556,000
1979	157,950	69	72,550	31	169,692,000
1980	175,950	62	80,300	38	201,266,000

California planting systems

Two planting systems, termed *summer* and *winter*, are used in California's commercial strawberry production, each requiring different management techniques.

Summer plantings are made from about mid-July in inland areas to September 1 in coastal areas, using plants dug the previous winter and stored at 20° F (−2.2° C). Summer planting of the University of California varieties is useful in all areas of California and is the dominant system in the central coast region.

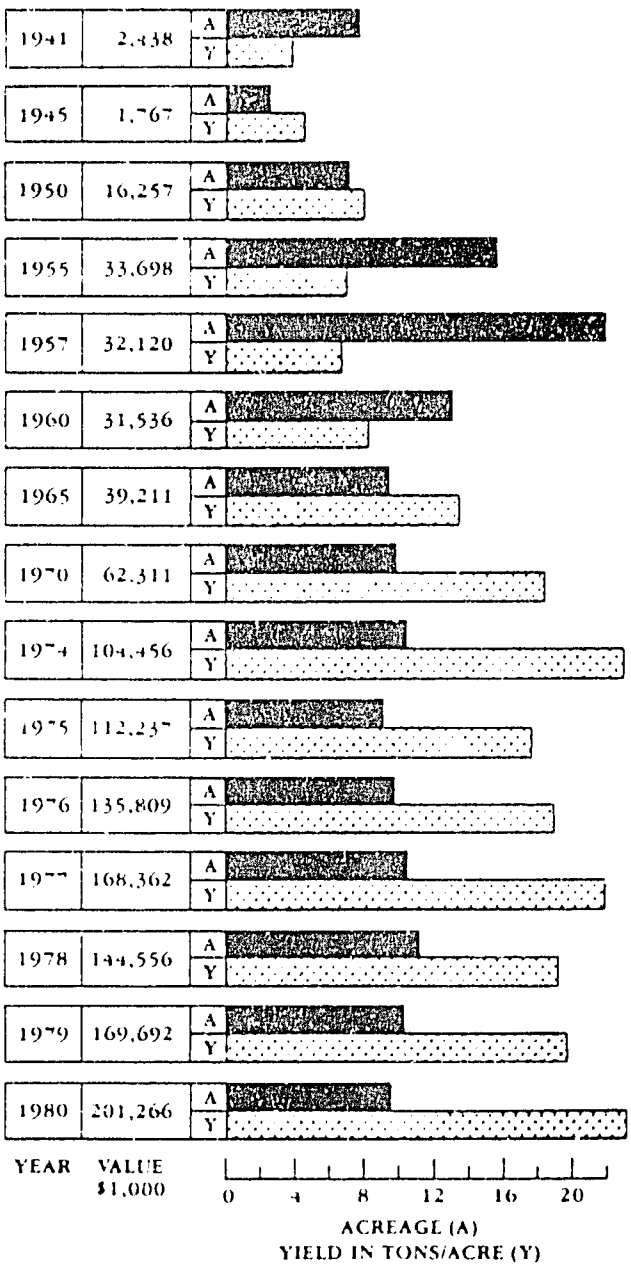

Fig. 1. California strawberry production.

Winter plantings are made from late October through early November, using current-season plants shortly after they are harvested from high elevation nurseries. The plants are stored in minimal cold storage (above freezing) and, normally, transplanted as soon after nursery harvest as possible. The success of such planting depends on active plant growth during winter—growth that is directly related to temperatures. The principal advantages of winter planting are early harvest, larger fruit size, ease of harvest, and lower production costs resulting from the much shorter time between planting and harvest. Winter planting is confined to coastal and semi-coastal sites that have relatively warm winters. It is the dominant system of southern California. Winter planting may be considered a "forcing" system, since plants are made to flower and fruit in a pattern not otherwise possible.

Some of the horticultural characteristics of the strawberry plant will help explain the physiological principles underlying the two planting systems. As do most deciduous fruit trees, standard strawberry varieties have both sexual and asexual reproductive cycles. Fruit buds are normally initiated during short days.

Vegetative or asexual growth, including runner formation, occurs mostly during the late spring, summer, and early fall after long days and warm temperatures.

Strawberry plants have a chilling requirement similar to that of many deciduous fruit trees. If the chilling requirement is satisfied completely during the winter, normal growth cycles occur. Flowers and fruit appear in the spring and early summer, followed by runners throughout the remainder of the growing season. However, in the south and central coastal regions of California where winters are relatively warm, temperatures are not low enough to completely satisfy the chilling requirement. When incomplete winter chilling is followed by cool summer growing temperatures, as in coastal regions, a prolonged fruiting period results. Such a prolonged fruiting period is characteristic of the Aiko variety. Periods of very hot temperature during the fruiting season tend to offset the effect of lack of chilling, driving the plants toward asexual reproduction and significantly reducing later fruit production.

Every variety has winter chilling temperatures for optimum performance. Insufficient winter chilling may result in weak plant growth and small, soft fruit with reduced shelf life. However, excessive chilling causes low fruit production and excessive plant growth and runnering. Choice of planting systems, time of planting, variety, and planting site are, therefore, important decisions in strawberry production.

Strawberry varieties

Tioga, introduced in 1964, dominated both planting systems in all of California's strawberry producing areas, but is now almost replaced by other varieties. It is outstanding in yield and firmness, and has been well accepted for processing. The color of its fruit is bright red and does not darken at high temperatures or delayed harvest; its calyx separates from the fruit easily. Tioga normally produces a large amount of fruit over a short time, particularly after abnormally cold winters and when summer temperatures are high. However, the fruit size of the later crop is small and lacks the characteristic long shape.

Fresno, introduced in 1961, was an important summer planting variety, particularly in the Oxnard area, but has now been almost completely replaced. As does the calyx of Tioga, the calyx (cap) of Fresno separates from the fruit easily, requiring special care in picking for the fresh fruit market. It produces a heavy summer crop when Tioga production is light.

Tufts (U.S. Pl. Pat. 3561), introduced in 1972, is adapted for both summer and winter plantings in coastal areas, when handled properly. It is an important variety in southern California where it has replaced Tioga in winter plantings. Tufts fruit is large, firm, and borne on long stems. The second crop on winter plantings is outstanding in appearance and is easy to pick. The fruit is bright red and tends to darken only slightly in high temperatures. Tufts produces good quality, well-shaped fruit far into summer, in contrast to Tioga. If it is summer-planted too early, the first fruit is rough. Sulfur injures developing fruit and should not be applied to the variety during the fruiting season. Other pesticides should also be used with caution on Tufts.

Douglas (U.S. Pl. Pat. 4487), introduced in 1979, is rapidly increasing in acreage in southern California where it performs particularly well in winter plantings, although it has been very productive in both planting systems throughout the state. It is the earliest ripening of all the University of California varieties and has by far the greatest adaptation to winter planting. The fruit is redder than that of Tioga, Tufts and Aiko and is exceptionally large and easy to harvest with very good flavor. Because it is not as firm as the aforementioned cultivars, care must be taken to harvest it frequently.

Vista (U.S. Pl. Pat. 4490) was introduced in 1979 as an early-producing cultivar for winter planting in southern California. However, Douglas has performed so well in that respect that growers have shown little or no interest in Vista.

Aiko (U.S. Pl. Pat. 3981), introduced in 1975, has replaced Tioga in the central coast. It is a late starting, heavy yielding, continuous cropping cultivar, well adapted to summer planting in the central coast. It is not adapted to winter planting. The fruit is medium in size, firm and slightly lighter in color than Tioga. As with Tufts, if Aiko is planted too early, pruned too early, or both, the early fruit is badly misshapen.

Pajaro (U.S. Pl. Pat. 4538), introduced in 1979, has performed well in summer plantings in the central coast, promising to be a good replacement for Aiko because it ripens earlier. It does not yield sufficiently under winter planting to merit recommendation. The fruit is large, firm, and attractive with red color similar to that of Douglas. It ships and handles particularly well, but the skin checks badly in heavy rain. The flavor is exceptional.

Establishing the planting

Where to plant. Because of the high capital investment required, it is important to obtain the best possible site. Certain conditions are necessary for successful strawberry production. Although strawberries will grow on most soils, deep, well-drained, sandy loam soils are best for the following reasons:

- They respond better to soil fumigation.
- Land preparation is easier.
- There is less salt accumulation over the life of the planting.
- They are better adapted to frequent harvest and irrigation schedules.
- There are few minor element (such as iron) deficiency problems.
- They drain better during prolonged rainy periods.

Avoid soils and waters that are high in salts. If the land slopes so much that extensive leveling is required, the site should be avoided, unless other advantages outweigh the expense of land preparation. It is important to quickly drain off excessive rain waters to minimize root rot diseases.

Water supply. An adequate supply of good quality water is essential for strawberries. Water should be analyzed by a commercial laboratory before strawberries are planted. For testing, collect samples from untested wells after the pump has operated for 30 minutes to an hour. Water for strawberries should have low amounts of sodium, chloride, and boron. Irrigation waters containing more than 700 to 900 parts per million (ppm) total salts may require special care in application to prevent salt accumulation from reaching toxic levels.

The amount of water needed will vary according to method of irrigation and type of soil. As little as 10 or as many as 50 gallons per minute per acre may be required. A 10-gallon rate is suitable under special conditions and requires continual pumping as well as a large reservoir of about 100,000-gallon per acre capacity to store water between irrigations. At a 50-gallon rate, water can be pumped as needed with or without a storage reservoir.

Drip irrigation. Many growers in central California and most growers in southern California are using drip irrigation. Drip irrigation is recommended and is particularly advantageous in areas with a marginal water supply, expensive water and soils with a high salt content, low infiltration rates, and poor drainage. With a drip system, beds should be graded to a 1-percent slope in order to drain off excessive rain water during the winter. Under drip irrigation, various practices such as spraying and harvesting can be carried out at any time, regardless of irrigation schedules. A single drip line will accommodate two rows of plants, and two lines are needed on the wide beds with four rows of plants in each. Drip irrigation causes much less fruit loss due to rot than does furrow irrigation.

The cost of installing and maintaining an effective drip system is substantial, and the installation should be carefully engineered and installed. Proper water filtration and pressure control are essential to a well-functioning drip system (see UC Leaflet 2740, "Drip Irrigation").

Land preparation. Proper land preparation is essential for good production. The soil should be well worked, free of clods, and reasonably dry when fumigated. The sub-soil should have been cross-ripped to insure adequate internal drainage. To minimize soil compaction, never work wet soil. Adequate soil aeration is essential for healthy root growth, plant vigor, and satisfactory yields. Crowns from the previous strawberry crop should be completely broken down because they interfere with proper soil fumigation. They may harbor organisms that may cause poor plant growth and low yields.

Application of manure within a year of planting is not recommended because of the salt load it adds to the soil and the hazard of adding weed seeds. A cover crop adds beneficial organic matter to the soil, but it must be incorporated into the soil far enough ahead of soil fumigation to have completely broken down.

The land should be leveled according to the type of irrigation to be used. UC Leaflet 2692, "Grading Land for Surface Irrigation," gives helpful suggestions on surveying and grading. Preplant soil amendments should be thoroughly disked into the soil after leveling to prevent pockets of salt concentration.

After the soil is leveled, fumigants should be applied by specially equipped and trained applicators. Growers should arrange for the application well in advance of the desired fumigation date. For best results, soils should contain a small amount of moisture (fairly dry) and be in excellent tilth. In general, fumigants disperse more efficiently in light soils. Fumigating with a mixture of methyl bromide* and chloropicrin* applied under a sealed plastic tarp is the standard practice in California.

The continuous tarp method (see fig. 2) is currently used. The tarp should not be removed until at least 48 hours after fumigation. The land is then ready for listing.

Strawberries should not be planted less than 15 days after fumigation to insure that no phytotoxic residues remain. High soil moisture, low soil temperature, high clay content, or lack of soil aeration through delayed listing may extend the waiting period. List the bed to a zero grade in the direction of furrows to insure proper irrigation. With drip irrigation, a slope of about 1 percent is desirable to allow excessive rain water to drain from the field. Good winter drainage will prevent the excessively wet soils that provide conditions suitable for the development of red stele and root rots.

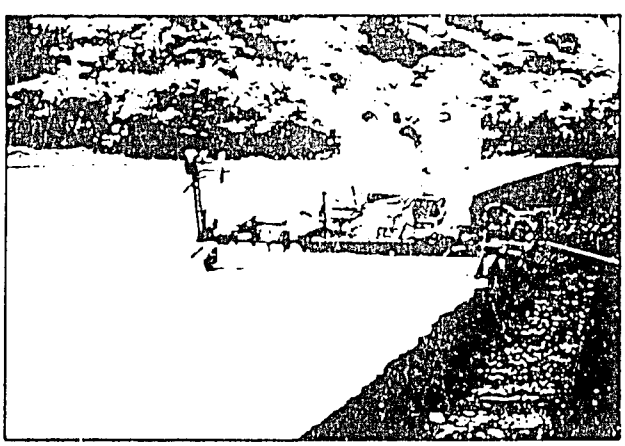

Fig. 2. A combination of methyl bromide* and chloropicrin* is applied under polyethylene tarp before planting.

*In California a permit from the county Agricultural Commissioner is required for purchase, possession, and use of this material.

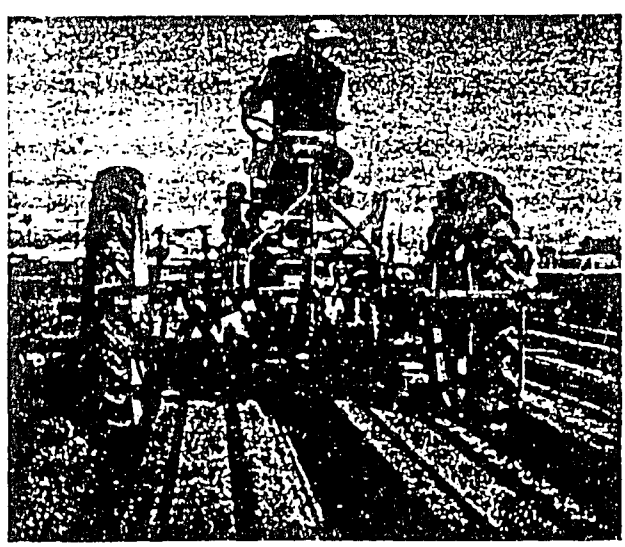

Fig. 3. Grooved beds ready for planting.

Nitrogen is the principal nutrient needed by strawberries in California. For winter plantings, slow-release fertilizers placed under the plants in the planting slot and covered with about 1 inch of soil as part of the planting operation, work best. For summer planting, all nutrients, including nitrogen, can be top-placed or sidedressed in bands in the beds, preferably after planting. Nutrients other than nitrogen are not mobile in the soil, and repeated applications may cause salty areas in the beds which are very damaging to plant growth and survival.

Transplanting methods. Plants are usually set by hand with a machine aid, although they may be set entirely by hand. The plants should not be allowed to dry out and should be sheltered during the entire transplanting procedure.

Figure 3 shows the machine aid most widely used in California growing areas. Plants are hand-transplanted into deep, narrow grooves on shaped, pre-moistened beds (fig. 4). Such grooves are opened by specially constructed discs and closed firmly by press wheels after the plants are loosely set. That method is recommended for best results.

Plants must be set so that the crown bud is exposed and the roots completely covered. Poor stands often result when the crowns are covered with soil. Poor plant growth results from setting plants too high, exposing the crown area where new roots initiate.

Plants should be sprinkler-irrigated as soon as possible after planting. Emerging roots are very sensitive to drought and salinity. Any condition that inhibits or slows growth will reduce yields. Regular irrigation is needed after planting and is necessary during dry periods in the winter. It is particularly important to irrigate summer plantings frequently during the first three months after planting. Sprinkler application rates should be slow enough to prevent the accumulation of free water in the furrows.

Plant spacing. Plant spacing will vary according to the cultivar, planting system, soil type, and grower's preference. Double-row beds are recommended for summer plantings and the four row-wide beds for winter plantings. The double-row beds vary from 40 to 52 inches, center to center, with about 48 inches perhaps the most efficient. The four-row beds recommended for winter planting range from 60 to 64 inches. Plant density varies from less than 20,000 plants per acre on some two-row beds to over 52,000 on some wide beds.

Summer planting

Plant storage. Plants for summer planting are produced in nurseries in low-elevation areas such as Red Bluff, Redding, and Waterford. They are dug when dormant in late December, January, or early February and stored until planting time.

After plants are harvested, they are cooled immediately to temperatures between 28° and 30° F (−2.2° and −1° C) to prevent growth of plants and decay organisms, which occurs at 32° F (0° C) and above. Temperatures below 27°F (−3°C) may injure or kill plants.

Plants are packed in standard cardboard cartons lined with thin film (0.75-mil polyethylene), and usually contain from 1,500 to 2,000 plants, depending on plant size (see fig. 5). Thick polyethylene film of 2 mils or more does not allow air exchange sufficient for respiration. Proper ventilation between the boxes is essential in cold storage to maintain a temperature of 28° to 30° F (−2.2° to −1° C) throughout the containers. If boxes are stacked too closely, the heat of plant respiration will raise the temperature in the boxes and promote plant and fungus growth, thereby reducing the storage life of the plants.

When to plant. Summer planting is recommended for current standard cultivars in central coastal California. The success of the system depends on planting the appropriate variety at the right time for a particular location (see table 3 for recommended time

Fig. 4. Transplanting strawberries in groove made by machine.

Fig. 5. Plants stored in ployethylene-lined carton.

for a given location and cultivar). Total yield, earliness, and fruit quality are all affected by time of planting. Optimum planting times for each variety are similar each year for a given location.

Planting too early reduces plant vigor, resulting in small, soft fruit. Planting too late results in excessive vegetative growth, reduced fruit production, and excessive runner development.

Variety and location determine the optimum planting time. Varieties such as Tioga should be planted earlier, whereas varieties such as Tufts, Douglas, Pajaro, Fresno, or Aiko should be planted later. If there is a choice, summer plantings should be planted in the following order for all locations: (1) Tioga, (2) Fresno, (3) Tufts, Douglas, and Pajaro, (4) Aiko.

TABLE 3. Planting Guide for Summer Planting*

CENTRAL VALLEY (Fresno-Modesto)	
Tioga	July 10 to July 25
Others	July 20 to August 5
CENTRAL COAST (Salinas-Watsonville-Santa Maria)	
Tioga	August 1 to August 20
Douglas, Pajaro, Tufts, Aiko	August 15 to September 5
(Early date Salinas—later date Watsonville)	
SANTA CLARA VALLEY (San Jose-Gilroy)	
Tioga	July 15 to August 1
Douglas, Pajaro, Tufts, Aiko	July 20 to August 5
SOUTHERN CALIFORNIA (Ventura-Orange-L.A.-San Diego)	
Tioga	August 1 to August 15
Fresno	August 10 to August 25
Douglas, Pajaro, Tufts	August 20 to September 5

*In general, the more inland the environment, the earlier the planting.

Management of summer plantings. Careful management of summer plantings during the first 4 months and, particularly, during the first 4 weeks after planting is critical. Soil should be thoroughly settled around the plant at planting time. High moisture levels should be maintained the first few weeks and during hot weather. Maintain optimum nitrogen fertility levels during the first 4 months. Well-grown plants always produce runners early during the establishment year after the "crown" fruit crop (fruit resulting from flower buds initiated in the nursery) and continue throughout the fall. Plant growth is enhanced if the flower buds are removed. Runners must be removed shortly after they appear to help promote large multiple-crown growth and prevent mat formation of plants. Insect control, especially of the two-spotted mite, is important in fall and winter.

Cultivation. A minimum amount of cultivation should be done in an established planting. Cultivation for any reason other than for bed maintenance, weed control, or perhaps for an occasional sidedress application of nitrogen is unnecessary.

Fertilization. Nitrogen should be applied as soon as possible after plants start growing. Total amount of nitrogen—if ammonium sulfate is used—should not exceed 30 to 40 pounds of actual nitrogen per application per acre to prevent salt burn or stunting. The last application of nitrogen should be applied as a sidedress immediately before application of polyethylene mulch. The amount of nitrogen needed will depend on plant variety and native soil fertility. If drip irrigation is used, slow release fertilizer can be applied in the center of the bed after transplanting and just before plastic is laid down. That practice will carry the crop through the harvest season if enough fertilizer has been applied.

Once polyethylene mulch has been applied where the field is furrow-irrigated, it is impossible to place fertilizers for most efficient use by the plants. Dry fertilizers can be applied only to the side of the furrow; liquid fertilizers can be applied through irrigation water. In both cases, most of the nitrogen is leached below the root system. Where drip irrigation is used, supplemental fertilizer can be applied in the water if enough is not supplied in slow release form at or soon after planting.

Fertilizer needs will vary according to variety, inherent soil fertility and soil type, and the efficiency of the irrigation system. Tioga has the lowest nitrogen requirement of any of the varieties discussed, but it may require up to 150 pounds of nitrogen per acre per year for top production. Excessive nitrogen can damage fruit quality and adversely affect the production pattern. Tufts, Douglas, and Pajaro, with intermediate requirements, may need up to 200 pounds of nitrogen per acre. Aiko requires the highest rate of nitrogen application—200 or more pounds per acre per year on sandy soils.

Avoid heavy nitrogen applications just before and during the heavy fruiting period for all varieties.

Pruning. Plants should be pruned after the first of February by removing only the senescent (old) nonfunctional leaves. (Healthy, vigorous plants will have four or more crowns.) Early or severe pruning reduces yield and lowers fruit quality.

Weed control. Most weeding is done by hand because it is difficult to operate conventional cultivating equipment in established strawberry beds. Soil fumigation with a combination of methyl bromide* and chloropicrin* before planting will kill most

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weed seeds. Such fumigation is especially important in plants where plastic mulch is to be used on established beds.

Several selective weed killers have been registered for use on strawberries. Because local conditions, residue problems, and regulations vary considerably, no specific recommendations are made here. (See UC Leaflet 2926, "Weed Control in Strawberries".) Follow labels carefully.

Winter planting

Winter plantings are satisfactory only in coastal areas where mild winter temperatures prevail. In southern California, winter planting is done for early fruit production, with the harvest beginning at least one month before fruit from the earliest-producing summer plantings ripen.

When to plant. Plants grown for winter planting are produced in areas of 3,000-feet (900 meters) elevation in northern California from mid-October to early November and shipped immediately to fruit-growing areas for planting. They should be planted only in warm winter areas where temperatures are high enough for them to grow actively during short days, thus initiating as many fruit buds as possible. The total yield per plant is only about one-half that of summer-planted plants because the winter plants are smaller. The differences in yield may be reduced considerably by increasing the plant density. Fruit quality and size are always better on winter plantings than on summer plantings, and the cost of harvest is less.

TABLE 4. Digging and Planting Guide for Winter Plantings

	Digging date	Planting date
	CENTRAL COAST	
Tioga	Oct. 10-Nov. 1	Oct. 15-Nov. 5
Douglas, Tufts	Oct. 10-Nov. 5	Oct. 15-Nov. 5
	SOUTHERN CALIFORNIA	
Tioga	Oct. 10-Nov. 1	Oct. 25-Nov. 5
Douglas, Tufts, Vista	Oct. 15-Nov. 5	Nov. 1-Nov. 10

Ideally, high elevation plants should be dug as near to November 1 as possible and planted immediately. (See table 4 for planting dates, varieties, and area.) Plants dug earlier (generally early October) with insufficient chilling are immature, lack vigor, and may produce poor stands. Experiments indicate that early-dug nursery plants will benefit from cold storage up to about November 1 to induce increased plant vigor and performance without causing the plants to runner. Additional chilling may occur in the field after planting, depending on location and the winter climate for that year. Excessive cold storage, or planting too late, causes early runnering and reduces yield. When storage of plants is necessary, they should be held above freezing. The Douglas variety adapts best to winter planting and has performed well over a wide range of planting dates.

Management of winter plantings. Firm the soil around the plant and sprinkle-irrigate after planting to provide adequate moisture in the upper root zone. Crown, flower bud, plant development, and some root growth will continue in the winter.

Fertilizing the winter plantings. Placement of fertilizer in the planting slot before planting is usually essential to the success of winter planting. Fertilizer can be placed in the bottom of the slot 6 to 8 inches deep and covered with about ½-inch of soil to prevent direct contact with roots. The application rate depends on type of soil. If fertilizer is placed where plant roots are, the plants are killed. If fertilizer is placed too deep or too far to the side, plants will not grow well because the roots do not reach the fertilizer before it is leached out of the root zone, or the roots reach the fertilizer too late to stimulate growth under cool soil conditions. Nitrogen fertilizer may be placed under the drip line as a supplement to slot-fertilization and will usually result in better growth during spring and summer than with use of side-dressed fertilizers.

Polyethylene bed mulching

Clear polyethylene mulch is a useful tool when used correctly: it warms the soil, increases early plant growth, and promotes high yields early. The mulch also reduces fruit decay and helps the fruit ripen more evenly, with a brighter finish and a cleaner fruit. Planting system, strawberry variety, and location determine timing of the mulch application.

Black polyethylene is not recommended because the soil is actually shaded and the temperature is the same as with bare ground. Furthermore, if air temperatures are high (90° F and over), the black mulch itself heats and the hot, black polyethylene scalds the fruit. In contrast, the clear mulch itself heats very little. The soil beneath it is heated much as in a greenhouse on a warm sunny day. However, when clear polyethylene is used, the weed problem must be minimized by fumigating the soil before planting to destroy most of the weed seeds.

White polyethylene mulch has been promising on summer plantings, but more research is needed. With winter or summer plantings, polyethylene mulch must cover the drip lines, if drip irrigation is used, to prevent fruit rot.

To apply polyethylene mulch, completely cover the shoulder of the bed leaving the skirt edges loose.

Wire loop pins or soil, placed at 6- to 8-foot intervals, will hold the mulch in place (see fig. 6).

One rule is applicable to all plantings: The later any given variety is planted beyond its recommended planting date, the earlier the plastic mulch should be applied. A rule for drip-irrigated plantings is that polyethylene bed mulch must be used to cover the drip tubes

Timing—summer plantings. Clear polyethylene mulch accelerates fruit production and can increase total yield. If plantings are properly timed, mulch should be applied after the plants are pruned and about to resume growth (after January 15 in southern California, and after February 15 in the central coast). If planting is later than the recommended dates or if plants are underdeveloped, mulch applied in early December may help increase yield.

Timing—winter plantings. With all University of California varieties, clear polyethylene mulch should be applied as soon after planting as is feasible. Timely mulching will increase total fruit yields, encouraging growth during the cold winter months by raising the soil temperature. If it is applied too late, it may reduce yields by stimulating early runner production.

Managing established plantings

Irrigation. In an established planting, frequency of irrigation will vary with soil type and time of year. In the spring it may be necessary to irrigate only once every 1 or 2 weeks, depending on rainfall. During late spring and summer, irrigate after each harvest, or every 4 or 5 days, by filling each furrow to the desired level as quickly as possible and shutting the water off. Level runs of 150 feet or less are easy to irrigate efficiently. The same principles of frequency and duration apply to drip irrigation. Monitoring soil moisture with a tensiometer is recommended for drip irrigation because of the tendency to over-irrigate. Drip irrigation should be run 3 to 5 hours to be sure that salts move past the roots and that most of the soil in the root zone is wet.

Salinity. The strawberry plant is one of the most salt-sensitive plants of California's major crops. Symptoms of excess salt vary with combinations of salts and plant variety. High total salt levels, regardless of source (fertilizers contain salts, for example), will cause stunting, marginal leaf scorch, loss of feeder

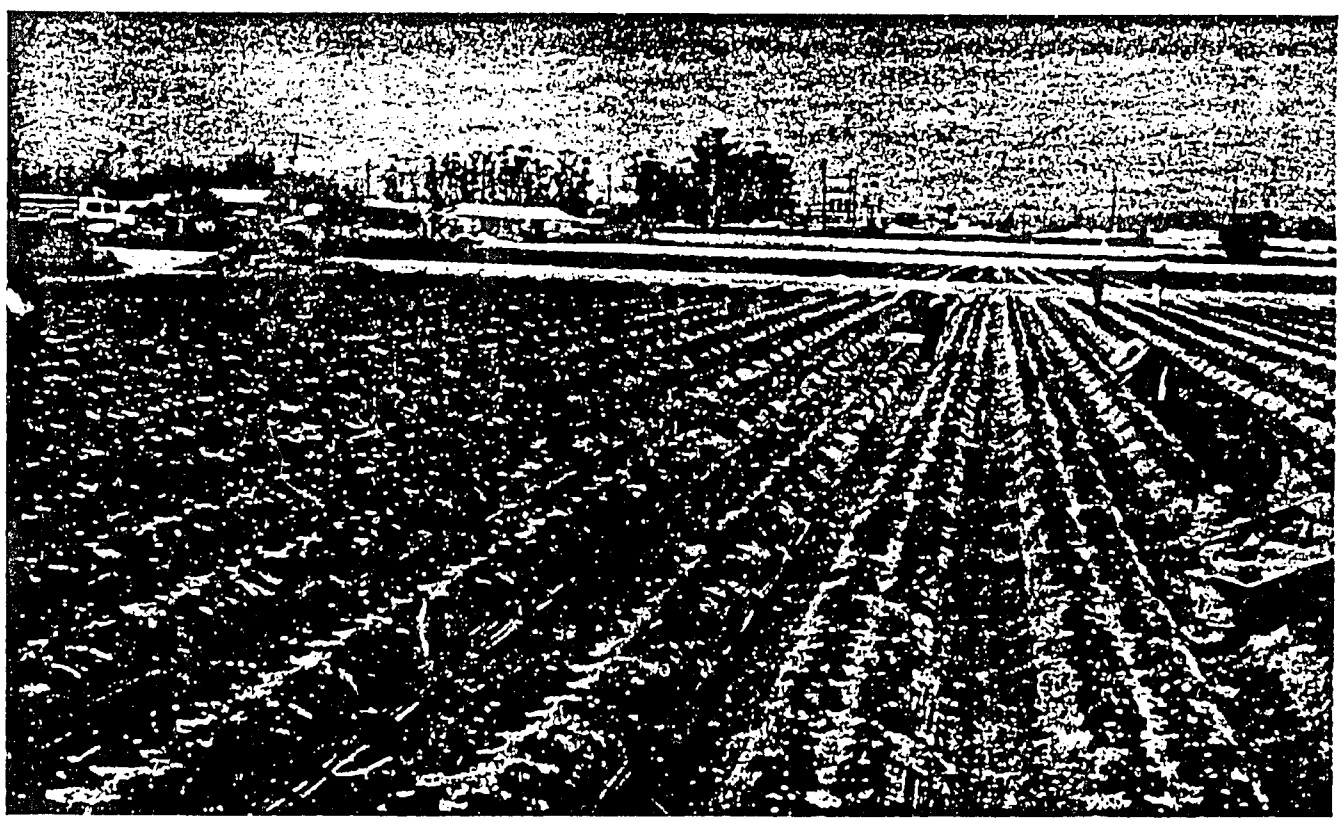

Fig. 6. Polyethylene mulch is applied shortly after pruning.

roots, and severe yield losses. High surface salt accumulation stops new root growth from crowns, and plants become loose in the soil. Considerable reduction of vigor and yield can occur before leaf symptoms appear.

All irrigation waters contain some dissolved salts, but if the salt content is low, irrigation and nutritional problems are minimal. Chemical fertilizers usually should be applied only after the newly set plants in a summer planting start to grow. Additional applications of phosphate or potassium fertilizers, or both, are usually unnecessary and add to toxic salt accumulation in the plant root zone. Such salt accumulations have, at times, caused considerable economic losses to growers.

Sprinkler-irrigate young summer plants until the polyethylene mulch is applied as needed even in winter months. Enough water must be applied to leach dissolved salts into the soil below the root zone.

Second year. In the central coast, some growers still carry plants over for a second year.

Pruning. After the first full harvest season, when plants are 14 to 18 months old, plants should be pruned heavily no earlier than mid-February by cutting off all but the very small leaves and some of the crowns with either hand tools or mechanical roto-beaters. As leaves are pruned, they should be removed from the field and destroyed as a sanitary measure. Control measures against two-spotted mites and other pests should then be taken.

Fertilization. First-year fertilization practices apply to all plantings. Good growth should be stimulated after harvest and before winter dormancy. The last application should be made before November when cold weather sets in. As with first-year fruits, excessive fertilizer use contributes to poor fruit quality and salinity problems in second-year fruits.

Harvesting and handling

Strawberries are harvested at different stages of maturity, depending on variety and how and where the fruit is sold. Fruit destined for fresh shipment to eastern markets should be pink or at most three-fourths colored. Overripe fruit bruises easily, deteriorates quickly, and decays in transit. Color for picking of University of California varieties differs considerably with variety. Berries for processing should be fully colored with the calyx and stem removed in the field.

Fruit quality is extremely important, whether the fruit is being harvested for processing or for the fresh market. Discard overripe or decayed berries—they detract from the appearance of the pack, and decay organisms spread rapidly.

Strawberries for fresh market are picked without stems by grasping the fruit lightly with the thumb and two fingers and removing it with a snapping motion. The fruit is packed directly into pint baskets holding about one pound (454 grams) of fruit each. The weight per pint basket varies with the variety and fruit size. Baskets are packed twelve to a tray. Berries for processing are capped in the field as they are harvested and placed directly into wooden or plastic trays without baskets.

For picking, most growers use a front-wheeled portable tray carrier. Strawberries are a tender fruit and must be handled carefully. Pickers must use extreme care not to squeeze the berries and to place them gently in the containers.

Picking in California extends from February to October, or even into November during years with warm, dry autumns (see fig. 7). The main production peaks always occur in May. At each harvest, and particularly after rain or heavy fog, overripe and decayed fruit must be removed from the plants to minimize fruit rot.

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
So. Calif.												
winter-planted		+	+ +	+ +	+ +	+						
summer-planted			+	+ + +	+ + +	+ +	+					
Fresno												
summer-planted				+	+ +	+						
Central Coast												
summer-planted				+	+ + +	+ + +	+ +	+ +	+	+	+	•
2nd year				+	+ +	+ + +	+ +	+	+	•		
winter-planted				+	+ +	+ +	+	+	•			

• Very low production
+ Light production
+ + Moderate production
+ + + Heavy production

Fig. 7. Strawberry production patterns in California.

Cooling. Strawberries are highly perishable and must be chilled immediately following harvest. Strawberries will not increase in sugar content after harvest. Strawberries have a very high rate of respiration and will deteriorate in a short time unless field heat is quickly removed. The quality lost in one hour at 85° F (30° C) is roughly equivalent to the quality lost in one week of storage at 32° F (0° C). Quality can be maintained and shelf life increased if the following rules are observed:

- Provide shade for fruit held in the field.
- Protect fruit from hot winds.
- Move fruit from the field to the cooler at frequent intervals during the day.
- Cool fruit as rapidly as possible and prevent rewarming.
- Protect fruit during loading and transit.

Packers, shippers and processors have adapted their facilities to accomplish rapid temperature reduction using forced air.

Diseases

Following are brief descriptions of serious strawberry diseases in California.

Soilborne diseases. Verticillium wilt is a soilborne fungous disease which attacks the vascular system of the plant. During warm weather infected plants wilt and outer leaves dry and turn brown, beginning at the tips and between the veins. Often the younger leaves die so quickly that they remain partially green. As cooler weather sets in, the plant may show some recovery, but that is seldom permanent.

Land that has been cropped previously to peppers, tomatoes, or potatoes, or land that has an abundance of nightshade weed, is often infested with the disease. The fungus that induces the disease has been known to carry over in the soil for 25 years. All of the cultivars listed herein are susceptible. The disease is controlled by fumigating the soil with a mixture of chloropicrin* and methyl bromide*.

Red stele, induced by *Phytophthora fragariae*, is a soilborne water mold fungus which kills the roots of strawberry plants growing in poorly-drained areas in which free water may stand during cool rainy seasons. The disease is considered native to certain California soils. Acid to near-neutral soils favor the disease. The disease may be detected by longitudinally cutting recently developed roots that appear to be partially collapsed. Such roots will show a reddish-brown discoloration of the core (stele) extending upward into the healthy looking part of the root. The disease is particularly apparent in early to mid-spring and may disappear as the season progresses.

Red stele may be spread by infected nursery stock, but that is unlikely now. The disease is widespread in certain growing areas. Because good drainage is the key to control of red stele, it is important to select well-drained land with no restrictive hard pan layer beneath the surface.

Vascular collapse, caused by another water mold *(Phytophthora cactorum)*, is also a serious problem on poorly drained soils, and the same control recommendations apply as those for red stele.

Black root rot is characterized by deterioration and premature death of the large, fleshy roots, and by failure of feeder roots to develop, or their early death. There are several soilborne organisms associated with the disease. Control can be accomplished by preplant soil fumigation with a methyl bromide*/chloropicrin* mixture.

Foliar diseases. Powdery mildew is common in the central coast area during late spring and throughout the summer. Leaves and fruit are susceptible. Infected leaves cup upward, become reddish on the underside, and, in severe instances, develop burned areas at the margins. Severe or prolonged mildew infection may reduce the vitality and productiveness of a field and impair fruit quality.

Treatment of the plants with approved fungicides or repeated dusting with sulfur reduces the disease, but the strawberry plant is sensitive to sulfur. Excessive rates of application with high temperatures during or immediately following application may burn the leaves. Sulfur should not be used on Tufts variety because leaves and the immature fruit can be injured.

Leaf spot is caused by the fungus *Ramularia fragariae*. The symptoms consist of small white spots with distinct reddish-brown borders and appear with overhead irrigation or during periods of repeated rainfall. Varieties differ in their susceptibility to the disease. Treatment of planting stock and field spraying with a suitable fungicide will reduce losses.

Bacterial angular leaf spot is a leaf spotting disease common during wet, rainy periods or under sprinkler irrigation during stand establishment. Lesions first appear as light green, water-soaked spots which enlarge to form irregular reddish-brown areas, eventually giving a ragged appearance to the leaves. A yellow bacterial ooze often appears on the under surface of the older leaves.

Virus diseases that affect strawberry plants are numerous. University of California varieties have a high degree of tolerance to most such viruses, but a combination of several viruses may cause a loss of vigor and production, as well as occasional plant symptoms.

It is important that only high quality planting

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stock be used, preferably California certified plants. However, the supply of certified plants is limited, and most California-plant strawberry nurseries grow plants in isolated sites, using certified plants as parent stock, producing plants of acceptable quality.

Fruit diseases. Gray mold rot is the most serious fruit rot of strawberries. It is incited by the fungus *Botrytis cinerea*. It is most serious during cool, wet weather and is responsible for fruit losses in the field, as well as in transit, storage, and marketing. Polyethylene bed covering, as recommended for use in summer planting, and proper application of fungicides will reduce losses.

Rubber or leather rot may be serious during excessively wet weather. It is caused by different strains of the same fungus that causes vascular collapse *(Phytophthora cactorum)*. Leather rot is a problem under furrow irrigation when the fruit hangs in the water of the furrows at irrigation time. There is much less leather rot under drip irrigation.

Insect and mite pests

Soil pests. Several weevils that can cause injury by feeding on strawberry roots are *Hoplia* (white grubs), *Nemocestes*, Fuller's rose, and *Otiorynchus (Brachyrhinus)* weevils.

Damage from adults feeding on leaves and fruit is unimportant relative to the damage that results from larvae feeding on roots. Plants wilt, the foliage turns reddish-brown, and the fruit becomes small and seedy. Injured plants often die. Field damage is characterized by gradually expanding areas of dying plants. The grower may frequently find larvae in the root area by digging plants. Effective control recommendations depend on proper identification of root weevils and by preventing reinfestation from other plantings in recently planted fields. Because identification is difficult and treatment varies, specimens should be submitted to the nearest farm advisor to identify the species positively.

Root lesion and root knot nematodes have been collected from both the roots of strawberry plants and the soil. When populations are high, root injury occurs. Lesion nematode injury can become a point of entry for other soil organisms. Control is by using clean planting stock.

Soil mealybugs are minute and nearly white, due to a thin covering of wax. Strawberries have been severely damaged when planted in fields from which infested fruit trees have recently been removed.

Garden centipede or garden symphylid, while not a common pest, can attack and kill strawberry plants. A root-feeding pest, the garden centipede is most likely to be a serious pest in fields where large populations had developed previously on other crops.

Aboveground pests. Spider mites frequently cause leaf injury, stunting of strawberry plants, and reductions in yield and fruit quality. The two-spotted mite can be recognized under a hand lens by a conspicuous dark spot on each side of the body. It produces webbing on the underside of the foliage.

Dusty conditions contribute to spider mite population increase and subsequent plant injury. With the aid of chemical sprays plantings should be kept as clean of spider mites as possible, particularly during late fall and winter months.

Aphids can damage foliage, stunt plants, cause smutting of fruit, and spread virus diseases. However, there is little evidence that spread of virus can be effectively reduced by controlling aphids in commercial strawberry fields.

Lygus bugs, even at low population levels, can cause catfacing (deformed fruit) of the fruit by feeding on young blossoms. Because poor pollination also causes catfacing, be certain that lygus bugs are the cause before initiating control measures.

Thrips are considered economically important pests in strawberry plantings, but the normal control program for aphids and lygus bugs will keep them below injurious levels.

Cyclamen mite is a difficult pest to control. It feeds in new-folded leaves and in unopened flowers, causing severe stunting, misshapen leaves, and shriveled fruit. The pest becomes most damaging in summer when temperatures are high enough for activity. It can be found by inspecting the small unopened leaves under a microscope or a 20-power hand lens. Follow the label in using the recommended pesticide. Annual planting with no carryover effectively eliminates the pest.

Spring dwarf nematodes have recently caused serious losses in some summer plantings in central coastal California. They have been associated with infected nursery stock and must be controlled at the nursery.

Several species of leafrolling caterpillars attack strawberries. They can be recognized by their characteristic habits of tying the leaves together and wiggling backward when disturbed. They do insignificant damage when feeding on leaves, but may burrow into the fruit.

Cutworms of several species may occasionally cause serious damage to young plants by eating out the central growing point, and cause less damage by feeding on the foliage. Some species, principally the rough-skinned cutworm, severely damage the fruit. Most damage occurs in spring and fall, with the fall attack being the more destructive. Baits provide better control than sprays.

Snails, slugs, and earwigs may damage fruit in strawberry plantings and can be controlled by application of baits developed for them.

State University Agricultural Center, H. Rouse Caffey, Chancellor
Cooperative Extension Service, Denver T. Loupe, Vice-Chancellor and Director

4 7/86 (10M) Rev

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Growing STRAWBERRIES in Louisiana

LOUISIANA COOPERATIVE EXTENSION SERVICE
LOUISIANA STATE UNIVERSITY AGRICULTURAL CENTER

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CAUTION!

Before using pesticides, READ THE LABEL and follow the manufacturers instructions.

GROWING STRAWBERRIES IN LOUISIANA

Earl Puls, Specialist (Horticulture)
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INTRODUCTION

Strawberries are grown as an annual in Louisiana and have been an important horticulture crop for many years. Although they are successfully grown in all areas of the state, the commercial acreage has been drastically reduced in recent years. This trend is attributed to hard-to-find hand labor, disease problems and competition from Mexico and other areas.

Harvesting of fruit normally begins in mid-March and lasts six to eight weeks.

If growers are to continue a competitive industry, they must produce high yields of quality berries at minimum costs. A major objective of the Louisiana Agricultural Experiment Station is to develop high yielding varieties of good quality that have some resistance to insects and diseases.

Producing strawberries is not a simple operation. To be successful, one must select the proper varieties; use insect and disease-free plants; control insects, diseases and weeds; fertilize properly, mulch, plant and harvest properly; and have adequate irrigation and frost control systems. In addition, proper harvesting and handling are very important.

This bulletin is intended to provide the commercial grower and home gardener with a better knowledge of strawberry production. For additional information, consult your local county agent.

VARIETIES

Probably the single most important factor in successful strawberry production is the selection of varieties adapted to the areas in which they are to be grown. The commercial producer will look for high yielding, good tasting varieties with good shipping qualities. The home gardener is probably more interested in flavor.

DABREAK was released in 1961 and has grown rapidly in popularity since its introduction. It is a productive variety for commercial fresh fruit and processing and home garden use and is adapted to the Gulf Coast area. The medium to large, firm, bright red fruit is very attractive on the fresh market. The large green calyx (cap) adds to the eye appeal and market qualities of the variety (Figure 1). For highest fruit production from plants of this variety, irrigation should be provided at frequent intervals. For strawberries of best size color and quality, fruit should be harvested every third day under average conditions.

Figure 1 - Large fruit typical of the Dabreak variety

Plants of the Dabreak variety are medium small in size and are slightly smaller than plants of the Headliner variety. This variety is less resistant to bird eye leaf spot (rust) than the Headliner variety.

Dabreak begins fruiting early in the spring and is very productive through late season. It is usually not as productive in north Louisiana as the Headliner.

TANGI (Figure 2), formerly known as selection L-63-377, was released in 1973 after having become the most popular variety in Louisiana. It is an excellent variety for commercial production, processing and home gardeners. Studies indicate that its fruit is equal to or superior to other Louisiana varieties. The medium to large fruit is firm and glossy. Early and total season yields of Tangi have been significantly higher than the Dabreak and

Headliner varieties. Frequent irrigations are usually required during the fruiting season for highest yields and quality.

Tangi is a vigorous medium to good plant producer with medium-sized dark green foliage and needs harvesting at approximately three-day intervals. It is resistant to leaf spot and leaf scorch, but the plant and fruit of this variety are susceptible to powdery mildew.

HEADLINER was released in 1957 (Figure 3) and is recommended as a high producer for both commercial and home garden use throughout the state. Five years after Headliner was introduced, it was recognized as the fifth most important variety in the United States in acres planted.

The large red fruit of Headliner is very attractive on the fresh market, and it is excellent for processing. Fruiting begins early in the season and continues until late spring or early summer. Large fruit size is a distinctive characteristic of Headliner.

Headliner is somewhat susceptible to leaf spot and scorch, but a spraying program will control these diseases satisfactorily.

Figure 3 - Headliner variety

LOCATION AND SOIL TYPE

The success of a strawberry planting can be influenced greatly by the site selected.

A deep soil with good surface and subsurface drainage should be selected. The soil should have adequate organic matter content and water holding capacity and be responsive to fertilizer applications. In addition, full sunlight should be available for proper growth and development of the plant and fruit.

Plantings should be made in an area where a good water supply is available for irrigation and frost control.

Figure 1 - Large fruit typical of the Dabreak variety

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Figure 2 - Large firm fruit typical of Tangi, formerly seedling No. L-63-377

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LAND PREPARATION AND FERTILIZATION

Before planting, be sure old crop residue is well decomposed and thoroughly mixed with the soil. Soil preparation should begin at least six weeks prior to planting.

Although summer cover crops such as cowpeas and soybeans are desirable, they should be turned under in August prior to setting plants in late October or early November.

If land to be used for strawberry production is in sod, cultivate it for at least one year prior to setting plants to help control soil insects.

If soil tests show that lime is required, make a broadcast application and thoroughly mix it with the soil in early summer prior to planting the cover crop.

The most desirable row width for planting is 42 to 48 inches. Rows should be prepared several weeks before planting and should be approximately 10 inches high after the soil has settled.

Apply fertilizer to the soil when preparing the rows. A general recommendation is 800 to 1,000 pounds per acre of 5-10-5 or its equivalent placed 6 to 8 inches under each row. If the plants are pale green, an additional application of nitrogen should be beneficial in February or March.

Specific information pertaining to the fertilization of strawberries grown under Louisiana conditions cannot be given in an article of this type since the actual amounts of the nutrients N-P-K to be applied as fertilizer will vary considerably from one field to another. This is true because of the different soil conditions present in the different fields as a result of different soil management (fertilization and cropping) practices that have been used among the fields. A soil analysis made from a representative sample of a field to be used for strawberry production will give some useful information about the fertility level and the reaction (pH) of the soil. These samples should be taken no later than the summer preceding the intended fall planting of strawberries. Once the results of the soil analysis are known, a person qualified to interpret the results in terms of strawberry production can predict with some degree of accuracy the amount of each nutrient that should be applied as fertilizer.

After the rows are prepared, irrigate them to firm the soil and dissolve part of the fertilizer prior to applying the plastic. If the soil is firm and moist at the time of transplanting, plants will usually not settle below the plastic, fewer plants will die, and growth and development of the plants will usually be good.

SOIL STERILIZATION

Fruiting Beds

The use of black plastic mulch provides an ideal opportunity for treating soil with sterilants, a practice used by many growers. Soil sterilization is effective for the control of soil fungi and bacteria, soil insects, nematodes and most weeds and grasses. Growers using this practice have reported increased yields.

Methyl bromide (MC_2) and ethylene dibromide (E.D.B.) are suggested chemicals to use in the rows when the plastic is laid. These two chemicals are liquids under pressure and must be applied with equipment designed for this purpose. (Check with your county agent for specifications.) Custom applicators are available in the strawberry growing area. Apply the chemical selected to a depth of approximately 6-8 inches on shaped beds during the same operation in which the plastic is laid (Figure 4). For best results leave

Figure 4 - Equipment for shaping rows prior to applying fumigant and plastic

the soil sterilant under the plastic for at least 48 hours. Remove the gas from under the plastic by making slits approximately 3 inches long in the plastic where plants are to be transplanted. Do this 2 to 3 weeks prior to transplanting. Make the slits in the plastic by hand or by mechanical means (Figure 5). A mechanical cutter can be made by attaching two triangular-shaped cutter bar blades evenly spaced on a 10-inch solid rubber wheel. The cutter can then be mounted on a front mounting bracket of the tractor and run over the top of the plastic, giving approximately a 16-inch spacing. An 8-inch wheel with two cutter bars ev[illegible] spaced will give approximately a 13-inch spacing. If double row plantings are desired, two wheels prepared in the manner described above and spaced about 10 inches apart will be needed.

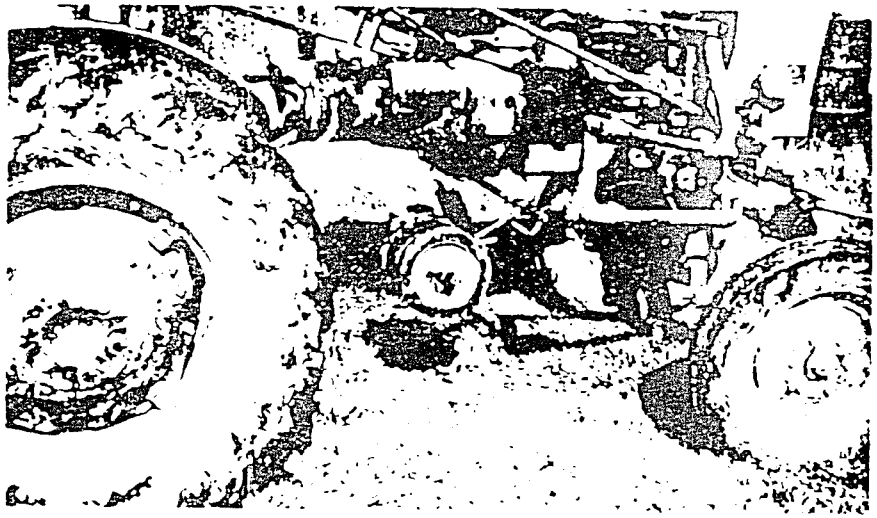


Figure 5 - Tractor-mounted cutter for cutting holes in plastic for transplanting

Plant Beds

Plant beds can be sterilized by using MC_3 or E.D.B., eliminating virtually all of the hand labor required for weeding. In addition, a cleaner and healthier plant can usually be grown in sterilized soil, provided the grower starts with clean plants. In plant beds the entire area should be sterilized as compared to only the soil in the rows of fruiting beds.

Mechanical equipment is available that applies the sterilant and glues the plastic covering all in one operation (Figure 6). Plastic 9 feet wide and

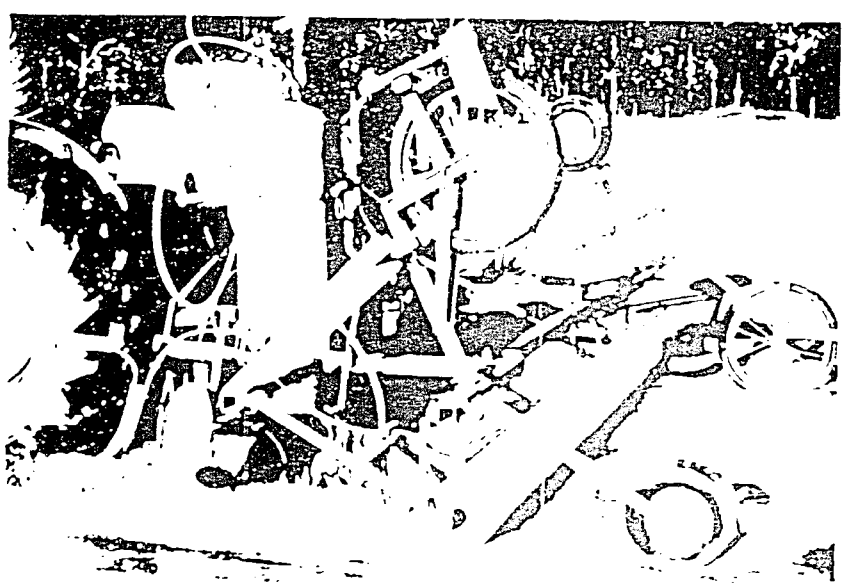


Figure 6 - One type of equipment used in applying soil sterilants broadcast

1 mil thick is used with mechanical applicators. When the plastic is laid by hand, 18-foot-wide material is used. The chemical is trapped under the plastic for at least 48 hours, and then the bed is aerated for 2 to 3 weeks before planting.

Before the sterilant is applied, the soil should be broken deeply and pulverized thoroughly since the chemical will penetrate only as deep as the soil is plowed. Soil moisture content is important, and the optimum time to apply sterilants is when the soil is in condition for working and planting.

After the soil is sterilized, take care to prevent the mixing of untreated soil with treated soil.

PLASTIC MULCH

Strawberries should be mulched to prevent splashing of soil particles on the fruit from irrigation and rain. For years, pine straw was used because of its availability. A number of years ago, black polyethylene replaced pine straw and is now used on virtually all commercial acreage. Advantages of plastic are that fruiting is earlier, some weed control is realized, soil sterilization is made possible, and in most cases, plastic is less expensive than pine straw.

Black polyethylene 36 to 42 inches wide and 1½ mils thick is popular with strawberry growers. When the material is applied to large areas, mechanical equipment is desirable and better results are usually obtained (Figure 7). Hand application of plastic can be made, but the task is rather cumbersome and difficult, and results are usually less than desirable. Regardless of how the plastic is applied, it is extremely important that it be snug to the surface and covered well on both sides of the row with soil.

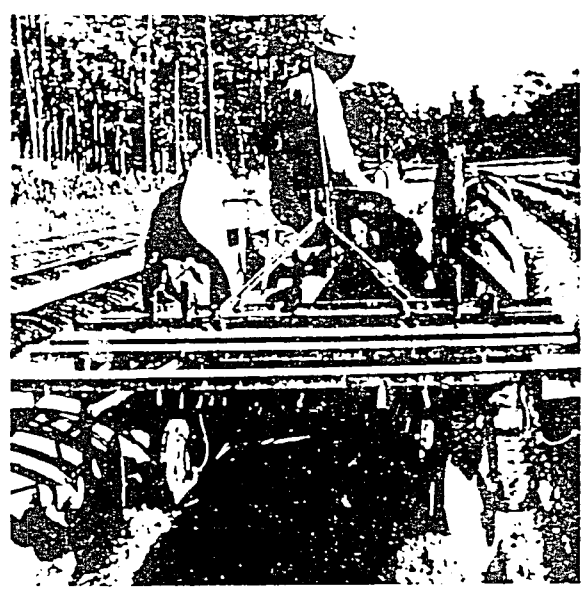


Figure 7 - Applying polyethylene mulch with

TRANSPLANTING

Only well developed plants with good root systems should be transplanted to the field. Transplant through previously cut slits in the plastic or punch holes in the plastic with a trowel (Figure 8).

On single planted rows, space plants 10 to 15 inches apart in the center of the row. On double planted rows, space them 13 to 16 inches apart alternately along the row with a 10-inch spacing between parallel rows. The variety will, of course, influence plant spacing.

Double-set rows usually yield more berries per acre, but single-set rows yield more fruit per plant. Cost of plants, plastic, soil sterilization, and the variety and availability of land should all be considered when making a decision on the planting system to use. When plants are expensive and land is not a factor, one might choose single row plantings. However, when costs of plastic and fumigation are considered, the cost per producing plant is usually less where the double row system is utilized. Approximately 12,000 plants will be needed for single row plantings, and approximately 20,000 for the double row system.

On double planted rows, the incidence of diseases and insects may increase since the dense foliage is harder to penetrate with fungicides and insecticides. Also, the excessive foliage on double planted rows sometimes makes harvesting a little more difficult.

Figure 8 - Cutting holes in plastic with a trowel and transplanting

Regardless of the system used, the bud and crown of the plant should be above ground and the roots below ground level. Plants set too high will suffer from root injury due to exposure. Those set too low will usually suffer from bud or crown injury (Figure 9). When transplanting, firm the soil

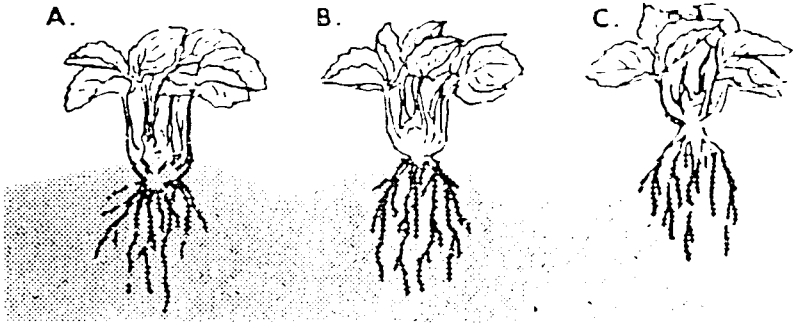


Figure 9 - Plant set too low (A); plant set correctly (B); plant set too high (C)

around the roots to prevent drying out. After a field is planted, preferably within hours, use a sprinkle irrigation system to water the plants. If sprinklers are not available, water each plant individually to settle the soil around the roots.

Avoid transplanting during periods of low humidity and when high north or northwest winds prevail since livability of plants is poor under these conditions. Best yields are usually realized when transplanting is done in late October or early November. Strawberries can be transplanted as late as mid-December, but yields are reduced proportionately.

Dig plants from the beds by hand with the aid of a long toothed fork or with a mechanical digger attached to the tractor (Figure 10). Shake excess soil off the roots. If not planted immediately, protect the roots from drying out by "heeling-in." Select a well drained area and place the roots of the plants in a trench, cover with soil and keep them moist.

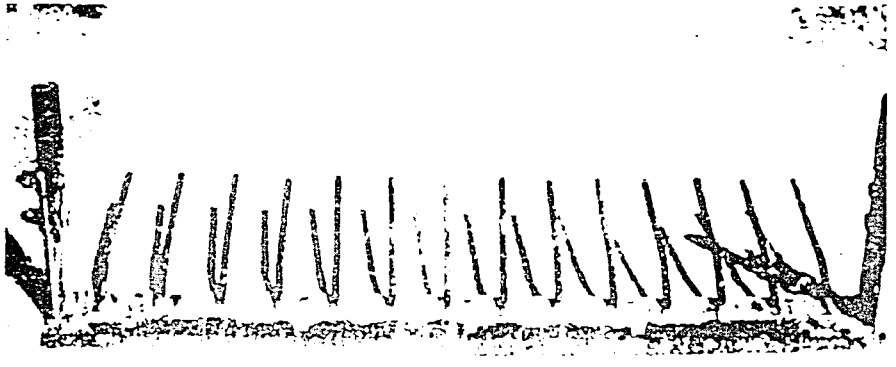


Figure 10 - Tractor-mounted equipment used to facilitate digging plants from plant beds

WEED CONTROL

The increased shortage and high cost of hand labor for hoeing strawberries have caused many growers to consider herbicides for weed control.

The use of black plastic as a mulch for the tops of the rows, and in many instances the use of soil sterilants under the plastic, have virtually eliminated the problem of weeds on the tops of rows. There still exists a problem between the rows.

The plastic makes mechanical cultivation difficult between the rows because it is invariably damaged or pulled up. Therefore, chemical weed control should be considered. For further information on this subject and specific chemicals to use, contact your county agent (Figure 11).

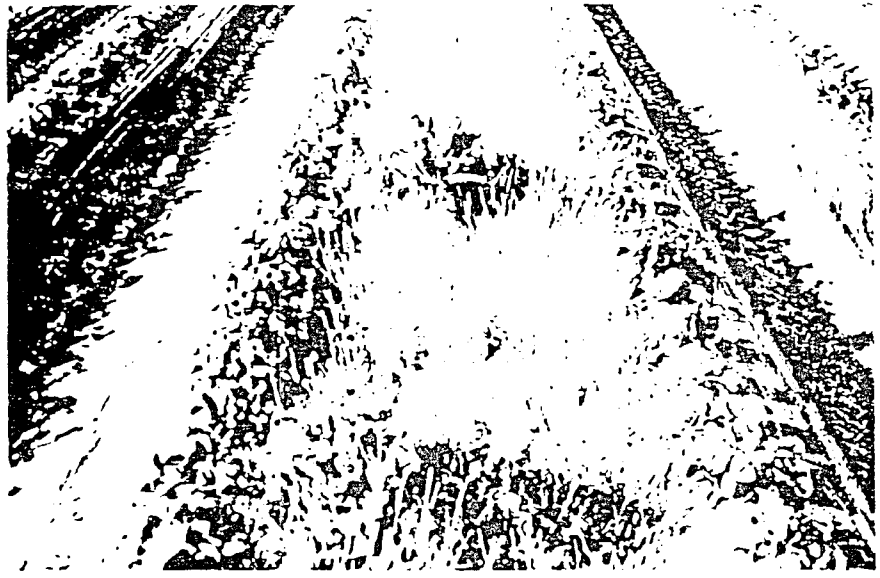


Figure 11 - Effectiveness of herbicide treatment is shown here

IRRIGATION

The strawberry is a shallow-rooted plant. Anyone growing this crop successfully must have irrigation facilities available for watering during dry weather. During periods of fruit production, at least one irrigation weekly is usually needed to provide adequate moisture on heavier soils. Lighter soils require more frequent watering.

Sprinkler irrigation is ideally suited for strawberry production because it can also be used for frost control. Small nozzles and a water pressure of 30 PSI or above is needed to form small droplets. The water should not be applied faster than the soil can absorb it. The amount of water being applied and the time required to irrigate strawberries are influenced by the nozzle size, sprinkler spacing, pressure and soil type.

FROST CONTROL

Sprinkler systems used for irrigation can also be used for frost control in strawberries (Figure 12). Smaller nozzle tips should be used. Place the equipment in the field ready for use before blossoms develop. Position the sprinkler heads to provide uniform plant coverage with an application of water at the rate of 0.1 to 0.15 inch per hour. Operating pressure should be at least 35 PSI.

Place a dependable mercury thermometer in the field to determine air temperatures. When the temperature drops to 34° F and is expected to go lower, turn the water on and leave on until any ice which has formed on the plants thaws. Do not be alarmed by ice on the plants. It acts as an insulator to prevent cold damage. Thermostats can be placed in the field to sound an alarm bell when the field temperature drops to 34° F.

Further information on frost control can be obtained from the Louisiana Cooperative Extension Service Agricultural Engineering Department.

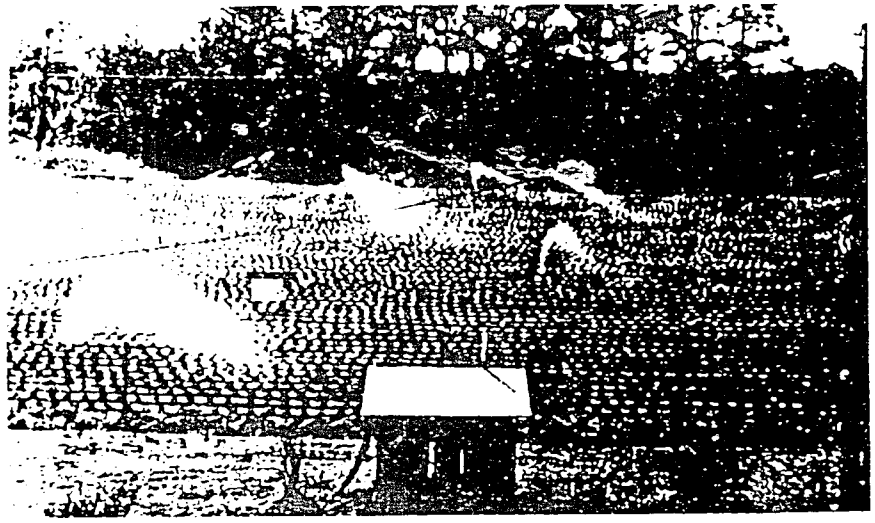


Figure 12 - Frost protection with sprinkler irrigation system

HARVESTING AND HANDLING

Harvest berries early in the morning when the weather is cool, and place them in containers that will minimize bruising. Select only firm, ripe fruit and pinch (rather than pull) them from the plant, leaving approximately ½ inch of stem attached to the fruit. Handle them carefully, and store in a cool place as quickly as possible after harvest. A harvest every third day is usually required for maximum yields of high quality fruit, however, this

varies with varieties and temperature. Rotten, deformed or damaged berries should be removed from the plant at each harvest.

Pack only firm, ripe, well shaped berries of good size. If overripe berries are packed, they can cause firm ones to decay before reaching their destination. The 12-pint jumble pack flat is the manner in which commercial growers pack strawberries in Louisiana.

After the fruit is packed, get it to the shipping point as quickly as possible since quality deteriorates rapidly at room temperature (70° F). When hauling to market, protect berries from heat and dust as much as possible.

When the berries reach the shipping point, they are inspected and graded, so it is to the grower's advantage to pack high quality fruit. Information relative to strawberry standards and grades can be obtained by writing to the Louisiana Department of Agriculture, Fruit and Vegetable Division, P.O. Box 44456, Capitol Station, Baton Rouge, LA 70804.

PLANT PRODUCTION

Strong healthy plants are a must in strawberry production. A grower can either raise his own plants or purchase them from a certified plant grower. A certified strawberry plant growers' list is circulated throughout the state in October and is available at the local county agent's office.

Two methods of producing plants are suggested for Louisiana growers:

Method No. 1—Set plants in single rows 12 to 15 inches apart on 4-foot sterilized beds in February. Use approximately 5 pounds of 8-8-8 fertilizer per 100 feet of row to encourage plant growth. These plants will multiply and produce additional plants for transplanting to summer plant beds in June to produce plants for fall transplantings. The blossoms produced by these plants should be pinched off as they appear. As the runners develop, root them in containers of sterilized soil as described in method No. 2. One hundred plants set out in February and properly cared for should produce approximately 1,000 plants for transplanting in June. These plants transplanted approximately 24 inches apart on 5- to 6-foot sterilized beds should produce a minimum of 20,000 plants for fall plantings if properly cared for.

Provide sufficient moisture for these plants at all times. No fertilizer is usually necessary when transplanting to summer beds, but approximately 200 pounds per acre of 8-8-8 or equivalent should be applied in September. After applying the fertilizer, make sure it is all removed from the foliage of the plants, harrow it in if possible and irrigate.

Method No. 2—As soon as the fruiting season is over and runner plants begin to develop, place small flats or pots lined with polyethylene and filled with sterilized soil on the tops of the rows near the mother plants. Do not remove the plastic on the rows at this time. Water the mother plants frequently to encourage runner development. When a sufficient number of runners are well rooted in each container, cut them from the mother plant and move the containers to a semi-shaded area for further plant development. Soil in the containers will dry rather quickly, so water frequently to maintain sufficient moisture for proper plant growth and development. After these plants are well developed, they can be transplanted in late June or early July to 5- to 6-foot sterilized summer plant beds. Place them 18 inches apart.

Although no fertilizer is usually necessary under the summer plant beds, apply approximately 200 pounds per acre of 8-8-8 or equivalent broadcast in September. After application, remove fertilizer from the foliage of the plants, harrow in whenever possible and irrigate. As the runners appear, pinch soil around them to encourage root development and space the plants evenly around the mother plants.

Although plant production will vary from one location to another, it is estimated that approximately 1,000 plants set out in June or July will produce approximately 20,000 plants for fall planting.

Moisture is very essential for good plant production, and an adequate amount should be available at all times. This will mean frequent waterings during the hot, dry summer months and in the early fall when an abundance of plants are on the beds.

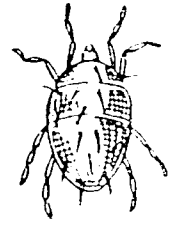
A good insect and disease control program must be practiced on plant beds to eliminate, or at least keep to a minimum, pests that might be transferred to fruiting beds in the fall. Controlling insects, especially the two-spotted mite, and diseases in plant beds is relatively easy since the plants are confined to a small area and this can help reduce the number of sprayings required after transplanting.

INSECTS

For a complete list of insect pests and recommended insecticides for control, consult the current strawberry insect control recommendations of the Louisiana Cooperative Extension Service.

Pesticides are poisonous and should be handled with care. Follow directions and heed all precautions on the container label. Complete spray coverage is essential for insect control.

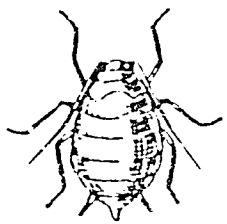
SPIDER MITES



Several species of spider mites feed on strawberries. They vary in size from 1/40 to 1/60 of an inch long, and some are barely visible to the naked eye. Their color ranges from a pale greenish-yellow to a deep red. The two-spotted mite is the most damaging of the different species found in the field and the most difficult to control. It is microscopic in size and causes severe chlorosis of the leaves and eventual death to the plant. Damage to

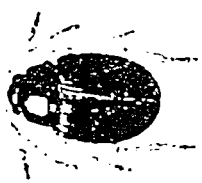
plants is most severe in the late fall and early spring. Thorough coverage of the plant when spraying, particularly the upper and lower surfaces of the leaves, is the key controlling the two-spotted mite. Weed control in and around the field helps reduce mite problems.

APHIDS



Several species of aphids feed on strawberries. These are soft-bodied insects, less than 1/16 inch when full grown. They feed primarily on new shoots and buds in the crown but may also be found feeding on the under sides of the leaves. Aphids are most numerous in the fall and early spring. They are live-born and can reproduce 5 days after birth. Although aphids can be blown in by winds, weed control in and about the field will help to reduce alternate host plants.

FLEA BEETLE

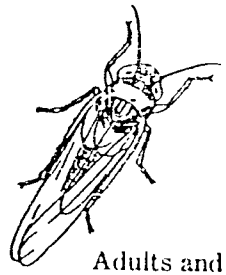


Flea beetles are small, dark jumping beetles about 1/16 inch long. They damage plants by feeding on tender foliage. Leaves which have been fed on look like they have been shot full of holes. Larvae are white-bodied, brown-headed, cylindrical and about 1/8 inch long when full grown. The adults are usually not observed because they jump readily when they detect movement.

LYGUS BUG

Adults are flat and about 1/4 inch long. They are brownish and marked with yellowish and black dashes and have a grassy appearance. Young nymphs resemble wingless aphids but are more active. Adults overwinter on herbaceous weeds and other plants in protected places. These pests suck juice from young berries, blossoms and terminals, causing abortion and deformed fruit. Where early populations are heavy, treatment of the headlands or adjacent ditchbanks will help to reduce populations. Burning of these areas during winter also will reduce populations.

LEAF HOPPER



The adult is a green insect about 1/8 inch long. It flies quickly when disturbed. The young nymph is tiny and light green. It is easily identified by its habit of moving sideways when disturbed.

Female adults deposit eggs within leaves and stems of strawberry plants. Nymphs develop on the undersides of leaves.

Adults and nymphs feed along the veins on the underside of leaves and suck juices from the plant tissue. While feeding, they inject saliva into the leaves. This plugs the sap-conducting vessels, and causes the leaves to become curled and stunted. Young plants suffer the most injury.

SPITTLE BUG

The adults are commonly known as froghoppers. They are about 1/4 inch long and either dull brown or mottled gray. Newly hatched nymphs are bright yellow. Spittle bugs overwinter in the egg stage. Eggs are laid in masses of 2 to 20 in a row, attached to stems and leaves of strawberries. Newly hatched nymphs feed on new growth, sucking out the juices. They produce a frothy material that covers their bodies. The nymph stage lasts 5 to 8 weeks.

Damage is caused by nymphs sucking plant juices from tender leaves and fruit. This may stunt the berries and weaken growth. Nymphs often attack flower bud clusters, leaf stems and young growth in the crowns. Adults are present most of the summer but do not cause much damage.

STRAWBERRY WEEVIL

This is a very tiny weevil about 1/10 inch long with a snout about half as long as its body. The females move into the strawberry fields in the early spring and puncture the flower buds with their long beaks and deposit their eggs inside. The weevils then girdle the flower stems, which results in the buds falling or hanging by a part of the stem.

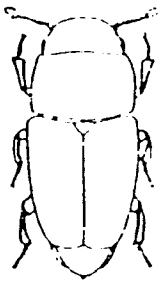
STRAWBERRY LEAF ROLLER

The larva of this insect is a pale green caterpillar about 1/2 inch long when full grown. The color ranges from pale green to gray-brown. It feeds on the leaves inside rolls which it makes by folding the leaflets along the midrib and tying them together

SNAILS AND SLUGS

Several species feed on the ripe strawberry fruits. Snails have shells, but slugs do not. They feed primarily at night and hide during the day under the mulch. Their presence is noted by the glistening trails of slime they leave on the plants. Control can be accomplished by the use of snail and slug bait.

SAP BEETLE



These are flat, brown beetles about 1/16 inch long, with the tips of abdomen exposed beyond the wing covers. The adults as well as the small, white grubs feed on the ripe strawberry fruits. They usually occur late in the spring about the end of the picking season. They are active and move fast when disturbed. They are attracted to the field by overripe, fermenting berries.

CATERPILLARS

Several leaf feeding species may infest strawberries and defoliate plants or skeletonize the foliage. Depending on the pest species, the damage may be widespread or isolated in small pockets in the fields.

DISEASES

Diseases of strawberries fall into five categories: leaf spots, fruit rots, crown rots, viruses and nematodes. Our leading varieties in Louisiana are susceptible to most of the diseases. Fungicides applied in a regular spray program will control leaf spot and fruit rots adequately. The summer crown rot fungus (Anthracnose), caused by *Colletotrichum fragariae*, can be controlled to some degree by using suggested methods of propagation, sanitation and fungicidal sprays. Root knot has been the most serious nematode pest, but it can be controlled by using a nematicide or soil sterilant.

A regular spray schedule using adequate spraying pressure to obtain good coverage of plant parts is essential for obtaining maximum production. Don't hesitate to ask your county agent how to spray and what equipment is necessary for good disease control. When rainfall occurs frequently, shorter intervals between fungicide applications may be required.

LEAF DISEASES

Leaf Spot – *Mycosphaerella fragariae:*

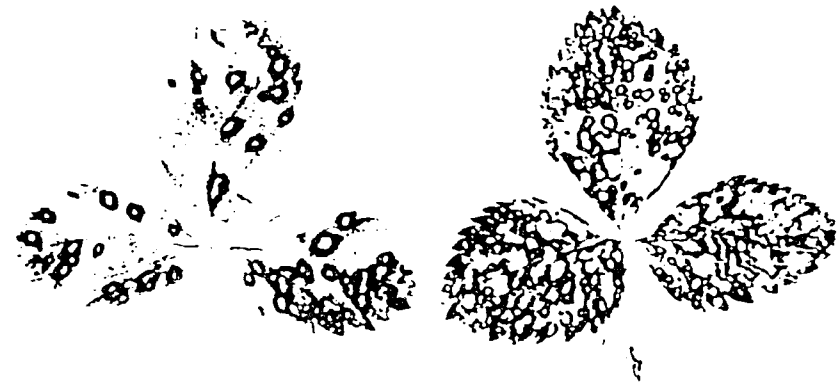


Figure 23 - Strawberry leaf spot

The local name for leaf spot is rust (Figure 23). The spots are small and purple when they are first formed. Mature spots are white to gray in the center surrounded by reddish border and may become as large as 1/4 inch in diameter. When spots are produced on the vigorously growing spring plants, they may be light brown with no reddish borders. The spots can become so numerous they cause the leaves to wilt and die. Leaf and fruit stalks and even fruit are susceptible, and plants severely spotted produce much fewer fruit than healthy ones. Some of the newer "California" varieties apparently are very susceptible to leaf spot.

Powdery Mildew – *Sphaerotheca macularis:*

The most conspicuous symptom of mildew is an upward rolling of the edges of the leaves. Also, a thin white growth of cobweb-like mold appears on the lower surface of the leaves and on stems and fruit. In severe cases, leaves may show purple blotches and may be killed (Figure 24).

Sulfur dust or Karathane can be used to control powdery mildew. Karathane is effective; however, it cannot be applied within 21 days of harvest. An emergency label for Bayleton was granted for the 1986 cropping season for controlling powdery mildew. This product should receive a full federal label in the future.

Leaf Scorch – *Diplocarpon earliana:*

Figure 25 - Strawberry leaf scorch

The first symptoms of scorch are very small, purple spots that appear on the upper leaf surface. They enlarge to form spots which are blotch-like in shape but never become gray or white in the center like leaf rust, described previously. A general infection may cause the leaves to look as though they have been scorched by fire (Figure 25).

Three other leaf diseases of strawberry plants usually are not of economic importance: purple leaf spot *(Mycosphaerella louisianeae)*, angular leaf spot *(Dendraphoma obscurans)* and Cercospora leaf spot *(Cercospora sp.)* Routine sprays to control other diseases will usually prevent these minor leaf spots.

CONTROL OF LEAF DISEASES

1. Spraying

Spray plants in plant beds every week to 10 days with Captan or fixed copper fungicides or every 10 days to 2 weeks with Benlate. Continue the same spray program after plants are set in the field until berries begin to form. At this time the only materials that can be used are Captan or Benlate. All of the above mentioned materials are effective for controlling leaf spot. It is not necessary to use more than one fungicide at each application, but alternating fungicides will prevent the fungus from developing a tolerance to the disease.

2. Sanitation

Several times during the summer months the dead leaves should be removed from the plant beds and destroyed. Such a practice will not remove much of the inoculum for leaf spot diseases which are not spread rapidly during the warm months, but do serve as a continuous source of the disease.

FRUIT ROT

Gray Mold – *Botrytis cinerea:*

Figure 26 - Gray mold on strawberry fruit

Gray mold is the most common fruit rot of strawberries in Louisiana (Figure 26). Growers must protect the fruit from this fungus as soon as the blossoms open. The first appearance of the disease on the fruit is a soft, milk chocolate-colored spot that may occur on any part of the fruit, but occurs most frequently at the stem end of the berry. The spot enlarges, involving the entire fruit. At this point the berry becomes powdery gray with masses of fungus spores. If one were to tap a gray-colored berry, the spores would drift off in the air as a small puff of smoke. Captan or Benlate will control gray mold of strawberries. Because there are numerous brands and formulations, growers should follow label directions. Read labels carefully before using any fungicide on strawberries.

CROWN ROT

Colletotrichum fragariae:

The crown rot that is caused by this fungus usually occurs in late spring and summer when day temperatures reach about 80° F. The disease has been found on plants during the fruiting season as early as April. It is characterized by a sudden wilt, as if the plant were broken off. Plants die within several days after they begin to wilt. The internal tissue of crowns of infected plants is reddish-brown.

Figure 27 - Plant suddenly wilting and drying from crown rot disease

The disease is common in plant beds where many mother plants as well as new plants die. The fungus frequently attacks the runners, in which case the newly formed plants will die if they are not sufficiently rooted (Figure 27). Research indicates that plants that die in the production field were infested in the plant bed the previous year.

Control of crown rot is best accomplished by sanitation and suggested plant production practices. It is important to get the newly rooted plants out of and away from the old field planting as soon as possible. Every effort should be used to obtain disease-free plants for propagation. Since the crown rot fungus overwinters in the crowns of the plants, the grower should destroy old stool plants as soon as possible.

Research is being conducted to obtain chemicals which will help control crown rot. At this printing, none are recommended, and Benlate has apparently lost effectiveness.

NEMATODES

Nematodes are worms or eelworms that are microscopic in size. Their presence on strawberry plants is easily noticed by the symptoms they produce

Dwarf – *Aphelenchoides besseyi:*

Dwarf has been called "crimp," "blind plant" or "wild plant." The nematodes feed on the unfolded leaves in the buds of plants, causing the expanded leaves to have a very unusual appearance. These new leaves are distorted and twisted, smaller and much narrower than healthy ones. They are often brittle and a darker green than normal, with somewhat of a greasy appearance. Thus, the disease gets its name from the peculiar leaf symptoms.

The symptoms of dwarf appear in the spring or early summer. Any plants that are diseased should be destroyed immediately. In summer beds it would be advisable to remove plants within a foot or two of the infected ones along the row, since the nematodes can be carried by splashing rain. It is possible that neighboring plants, even though they appear healthy, are infested but not yet showing symptoms.

Root Knot – *Meloidogyne hapla:*

Figure 28 - Strawberry roots showing root-knot nematodes

This nematode attacks the roots of strawberry plants, causing numerous swellings or galls to form (Figure 28). Branch roots appear to grow from the galls so the abnormal condition is easily distinguished from the normal growth pattern of healthy roots. In addition, the roots of infested plants deteriorate, become discolored and eventually blacken. Severely infested plants are greatly weakened so that yields of plants and fruit are significantly reduced

Root knot nematode can be controlled in several ways. Application of a liquid nematicide such as methyl bromide, chloropicrin D-D mixture, Telone II, or Telone C-17 can be applied with tractor-operated equipment.

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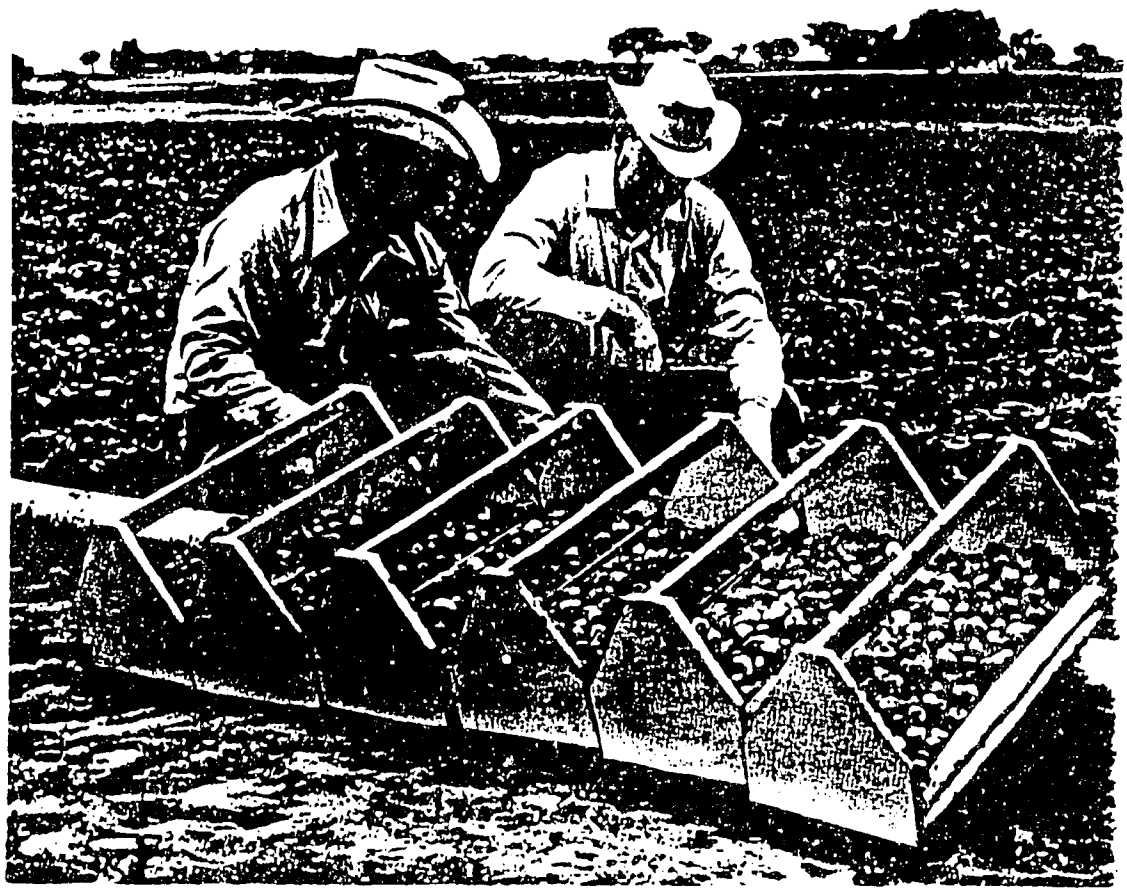
TEXAS STRAWBERRIES



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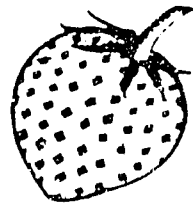

Texas Strawberries

George Ray McEachern and Bluefford G. Hancock*

The strawberry is a very vigorous plant and can thrive under a wide range of conditions. However, to produce a profitable crop, definite practices are essential.

THE STRAWBERRY PLANT

The strawberry plant has three basic parts—the roots, crown, and leaves. The *roots* are shallow and very diffused, thus absorbing mineral nutrients and water mainly from the top 8 to 10 inches of soil. A productive plant must have a strong disease-free root system.

The *crown* is located at the soil line and is made up of woody stem tissue. It is the site of leaf and fruit bud initiation, plant support and storage of food reserves. A strong, thick crown is essential for good leaf and fruit production, as well as for plant survival during stress periods.

The *leaves* are food-manufacturing sites. Under ideal conditions, they will produce two or three times their own weight in berries. The leaves must remain disease-free and should not be allowed to wilt excessively.

While the strawberry plant maintains world-wide distribution and culture, very few varieties produce efficiently in all climates and locations. Strawberries form flowers (reproductive stage) when the days are short and the nights are cool. In contrast, the plants will produce runners (vegetative stage) when the days are long and the nights are warm. Because of varying climates, no one variety has been extensively grown throughout the nation or Texas.

PRODUCTION AREAS

Texas has two major strawberry production areas, South Texas and East Texas. The everbearing strawberry is grown in West Texas home gardens. Many of the cultural practices required in these areas are the same and are covered in this publication as a unit. Special reference to varieties and planting system suited to each area is included also.

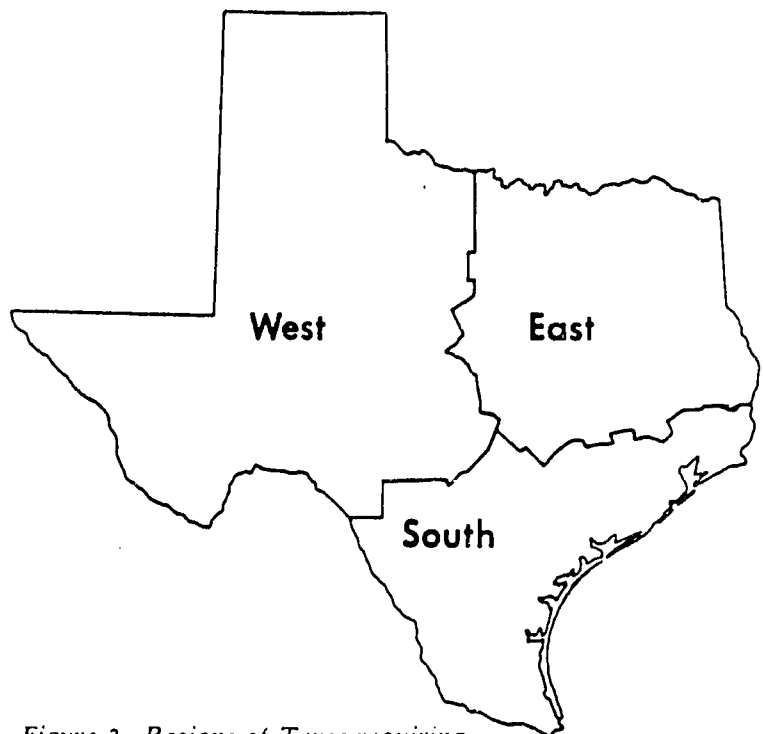

Figure 2. Regions of Texas requiring different cultural methods.

SITE SELECTION

Since strawberries are an extremely high investment crop, growers should plant them in their best soil.

A raised location with a slight slope which is free of frost pockets is an ideal site. Avoid low,

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flat heavy land with a high water table. Select a site that is well drained.

Sandy loam soil is ideal for strawberry production. When grown as an annual crop, strawberries should be on the same land only 1 year out of 3.

Full sunlight is needed for best plant growth.

SOIL PREPARATION

Work the soil thoroughly to insure good soil structure and elimination of weeds. Begin preparing your soil at least 6 weeks before setting plants.

Pastures, fields or permanent sods should be farmed to row crops for at least a year before planting strawberries.

In the fall or spring, plow the soil 6 to 8 inches deep to facilitate planting.

Take soil samples before cultivation to determine the fertilizer requirements and possible nematode infestations.

If high populations of nematodes are found, preplant soil fumigation will be needed.

In following the fertilizer recommendations, incorporate the fertilizer as the rows are built. If a polyethylene mulch is used, apply the entire recommended rate 2 weeks before the final row dressing. When straw is used as a mulch (spring planting system), apply half of the recommended rate at the time of row building.

FERTILIZER

Apply fertilizer before setting plants in the field. If polyethylene mulch is used, apply 800 pounds per acre of 6–12–6 or its equivalent in other grades. Place the fertilizer directly under the area where you will set the plants. Prepare the bed immediately following fertilizer application.

When straw is used to mulch plants, apply the fertilizer at the rate of 400 pounds per acre before planting and 400 pounds per acre 4 to 5 months later (mid-August).

IRRIGATION

Irrigation is necessary for profitable strawberry production in Texas. During the growing and production period, the plants need a continuous supply of moisture. Since most strawberry production is on sandy soils of low water-holding capacity, frequent irrigation is necessary. When the leaves begin to wilt or "produce a silver curl in the wind," it is time to irrigate.

Furrow irrigation is the common method. However, newly planted strawberries should be sprinkler irrigated daily for at least a week to reduce the shock of transplanting. Spring-planted strawberries should be set during the rainy season. In late spring when plants are large and fruiting, irrigation may be needed every 3 to 6 days. During the harvest season, growers should schedule irrigations after each picking, if no rains occur.

Trickle or drip irrigation is receiving wide adaptability throughout Texas and the United States. Black polyethylene pipe with emittors set every 18 to 36 inches have increased strawberry yields at College Station. At a pressure below 15 p.s.i., emittors should release 1 to 1½ gallons per hour. A filter system is essential in preventing emittor stoppage. Soil moisture and plant wilting symptoms will determine how often and how long the trickle irrigation system should operate.

Strawberry plants are salt sensitive, and should not be planted in saline soils. Irrigation water containing over 400 p.p.m. total salts should be considered potentially hazardous, and used only to prevent plants from dying. On soils relatively high in salts, a program of light fertilizer applications should be made with frequent (leaching) irrigation. Late afternoon is the best time to irrigate.

Excessive irrigation can be harmful. Water should not be present in the row middles 3 to 4 hours after irrigation. Excessive amounts of water reduce the oxygen supply to the roots.

Irrigation promotes weed growth. Plan to use a plastic mulch, straw mulch, herbicide or hand cultivation.

MULCHES

The use of polyethylene film for mulching strawberries has become a standard practice in the larger commercial production areas of the country. It results in earlier and cleaner fruit, conserved moisture, reduced fertilizer leaching, less bed erosion and, most important, weed control. Some disadvantages are that this film is an added cost, constant bed shape is necessary and hand labor is required to remove it at the end of the season. Use of polyethylene film is also difficult when the East or West Texas biennial planting system is used. Use polyethylene film 3 feet wide and 1 to 1½ mils thick. The film can be applied by hand or with a tractor-drawn applicator. Cut a trench in each side of the row, 4 inches wide and 6 inches deep. Pull

the film down the row, stretch it (to take out the wrinkles) and place the film edge in the trench and then cover with soil to hold it firmly in place. Polyethylene mulch also can be applied after the plants have been set out. Follow the above procedure and cut holes for the plants and pull them through. The soil should be moist when the film is applied.

A straw mulch works well for plants grown on the spring biennial system. This mulch could include pine needles, saw-dust, oats or wheat stems, hay, ground bark or any other similar organic material. It should be applied before the second spring.

In West Texas, the straw should be applied in the fall and pulled over the plants for insulation against extreme cold periods and wind. As the weather warms, uncover the plants.

PLANTING

Only top-quality, virus-, nematode- and salt-free plants should be used. Cost of plants is small compared to other expenses involved in successful strawberry culture.

Plant setting is a critical operation in strawberry culture. Assign dependable workers to this job.

Plants should be set at the same depth at which they were grown, which is the mid-point of the crown (see figure 3). When they are set too deeply, soil will be washed over the crowns by rains or irrigation water and the plant will die. Shallow planting exposes roots, which also results in death of the plant. Use a trowel to set plants.

For commercial plantings, use a small spade. One man opens the space for the plant and the second man sets the plant at the proper depth. Then the man with the spade presses his foot against the plant to firm the soil.

Avoid setting plants directly in the band of concentrated fertilizer. The roots should not be allowed to dry out, and should be protected at all times from exposure to sun and wind. Ideally, the plants should be set during cloudy days or late in the afternoon so that they have some time to establish themselves before being subjected to hot sun.

Irrigation should immediately follow transplanting and be repeated daily for a week.

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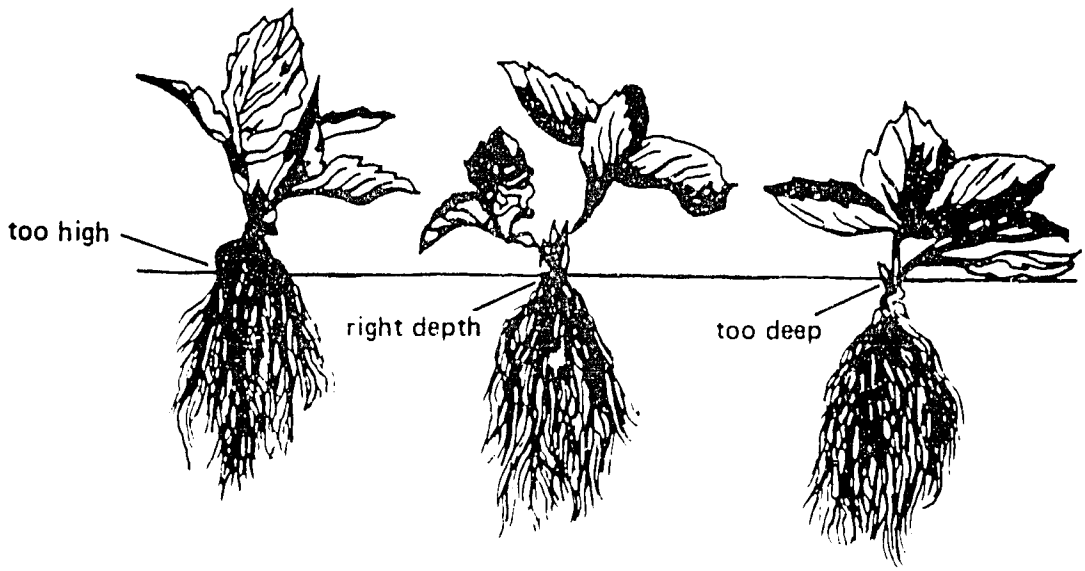
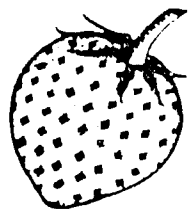


Figure 3. Proper planting depth for strawberries.



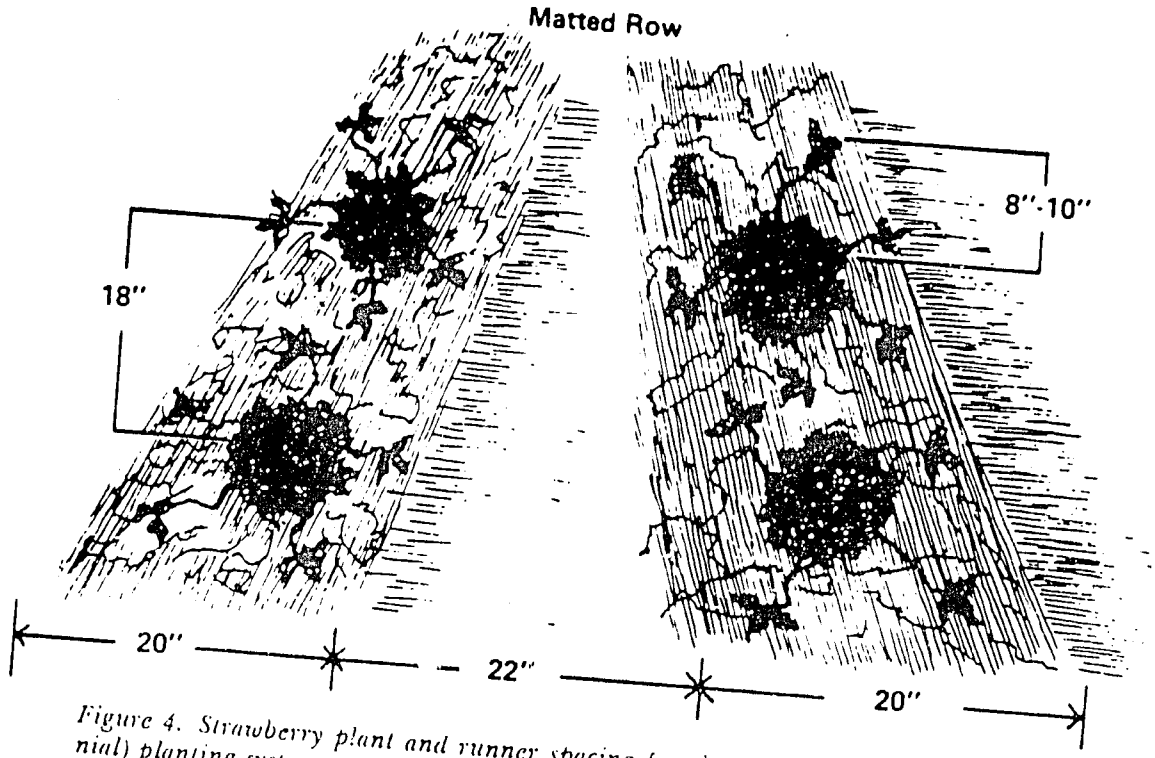


Figure 4. Strawberry plant and runner spacing for the East Texas spring (biennial) planting system.

EAST TEXAS

Spring (Biennial) Planting System

Strawberries grown north of Houston and Austin should be planted in a spring planting system. The plants are set one spring and strawberries are harvested the following spring.

Preparation

The plant beds should be cultivated 6 to 8 inches deep. All weeds must be killed. Make the first fertilizer application 2 to 3 weeks before setting the plants.

Soil samples may be examined through your county Extension agent's office by the Extension Plant Pathology Laboratory, College Station, Texas. If nematodes are present (as shown by root-knot galls on previous strawberry roots or soil test) preplant soil fumigation is essential. Soil fumigants should be applied at least 2 weeks before planting.

Planting and Bed Development

All spring-planted strawberries should be virus- and nematode-free. Set plants 2 or 3 days following a spring rain or sprinkler irrigation.

Make the bed 42 inches wide and no higher than 4 inches. Set plants 18 inches apart down the center of the row. "Stick" five runners 8 to 10 inches from the mother plant as they develop. A 20-inch matted row should be maintained. About 8,000 plants are required per acre.

After Planting Care

The first growing season is devoted to making a matted row of strong plants; remove the flowers developing the first season. Control weeds as well as possible. Make the second split fertilizer application in mid-August. This precedes fall flower bud initiation. The plants will go into a slow growth stage during the winter months.

Apply a straw mulch during January or February.

Production Season

The second spring is the only harvest season. Berries will be produced during April, May and June. Allow the plants to fruit only one season because problems (weeds, thinning, diseases) greatly exceed yields and profits. It is more profitable to begin with new plants each year and fruit them for one season.

Pick Your Own

The "pick your own" marketing system has added new interest to the strawberry industry in East Texas. Harvesting laborers are becoming more and more difficult to obtain. Customers can go into the field and pick their own berries at a lower price. "Pick your own" allows the purchaser to get the best quality berries and at the same time the grower reduces harvesting labor problems. Pick-your-own markets are not always present, so a grower should study his potential market before

establishing such an operation. Try a small planting several years before going into a large pick-your-own operation.

SOUTH TEXAS

Fall (Annual) Planting System

Strawberries grown south of Houston and Austin should be grown on a fall planting system. Set the plants in the fall for harvest the following spring. During exceptionally warm winters, berries may be harvested as early as December or January. The early harvests reduce the crop during the normal season.

Preparations

Begin land preparation in late August. Nematocides, if needed, should be applied at least 2 weeks before planting. Kill perennial weeds by cultivation. Add commercial fertilizer 2 weeks before planting, and sprinkler irrigate 5 days before setting plants. The soil should not be dry or soggy at planting time. Apply black polyethylene mulch just before planting.

Planting

Fall plants usually are set the last week of September and in early October.

Set plants in a double row on a 42-inch bed, with the rows 12 inches apart. Space plants 12 inches apart in the row. They should be set alternately rather than opposite each other. About 25,000 plants are needed to set one acre.

Planting should be on cloudy days or late in the afternoon, so that the plants can establish themselves overnight before being subjected to the hot sun. The roots should not be allowed to dry out and should not be dropped far in advance of the setter.

Plant Source

Plants used in the fall system are produced from virus- and nematode-free mother plants. A mother bed, 6 feet wide and fumigated with methyl bromide to kill weeds, nematodes, fungi and insects, should be prepared in late February. Immediately after purchase, plant the mother plants 36 inches apart down the center of the bed. If weather does not permit setting, store the plants in a cooler at approximately 35 degrees F. The initial runners can be transferred to fumigated mother beds for additional plant multiplication. Light tillage and runner "sticking" will increase the final number of plants produced. The mother beds must be irrigated every 3 days in the summer unless it rains. This keeps the soil cool enough to allow good growth. Under optimum conditions, 30,000 to 50,000 daughter plants can be produced for fall setting from 1,000 mother plants. The plants are ready for transplanting when vegetative growth (runner production) reduces to a low level.

After Care

Immediately following setting, the plants should be sprinkler irrigated. A 15 to 30 minute sprinkling is recommended daily for 7 to 10 days. Winter rains and furrow irrigation are used to supply water for the remainder of the season.

Production

The quantity, quality and earliness of winter-planted strawberries depends on the amount of growth the plants make during the winter period. Flowers will be produced once the plants are well established and growing. Late frosts will determine the earliness of the season. The first consistent harvests should be in early March.

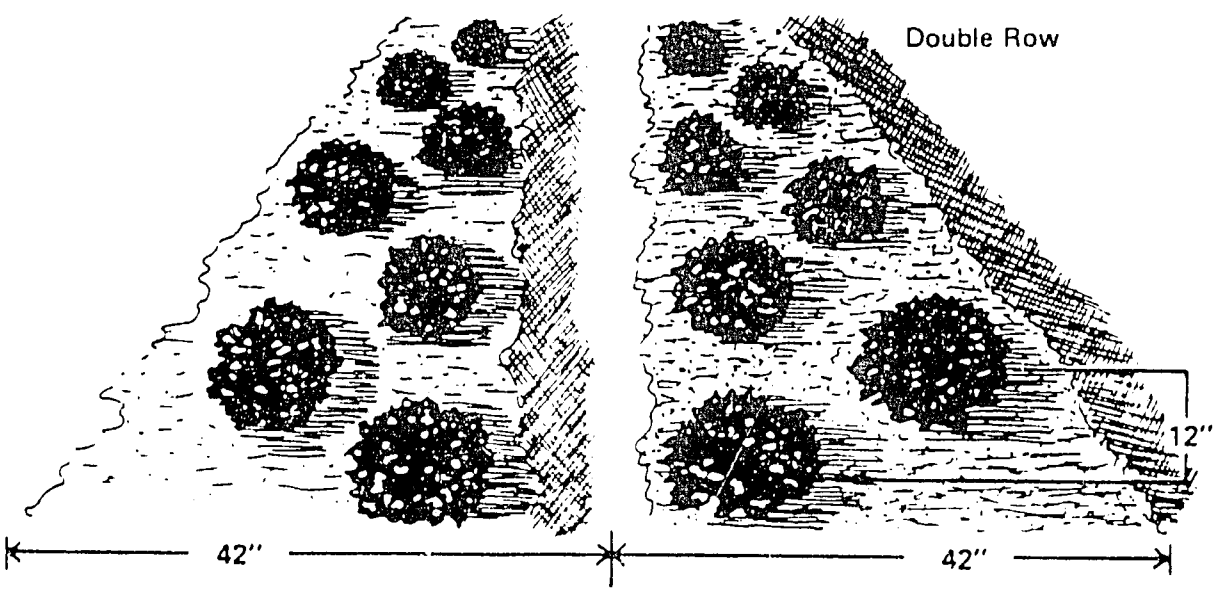


Figure 5. Strawberry plant spacing for the South Texas fall and summer (annual) planting system.

SOUTH TEXAS

Summer (Annual) Planting Season

Several strawberry producers in South Texas store a limited number of plants under cold storage conditions for direct sale to growers in August or September. Land preparation, fertilization, planting, mulching and irrigation are the same as for fall planting.

The grower should kill all plant parasitic nematodes (sting and root knot) before summer planting, since August is a period of high nematode population and activity.

Purchase disease-free plants which have been grown in a salt-free soil. Set the plants 12 inches apart in double rows in the spring as soon as the soil is manageable. Sprinkler irrigate the first 2 weeks, and by furrow thereafter as needed. Do not place the plants on a ridge because salts will accumulate at the highest point. Remove all flowers and runners that form the first spring. A fall crop can be harvested. Mulch the plants with straw for protection during cold periods (below 20 degrees F). See section on mulches. Completely cover the plants. As the weather clears, pull the mulch off the plants.

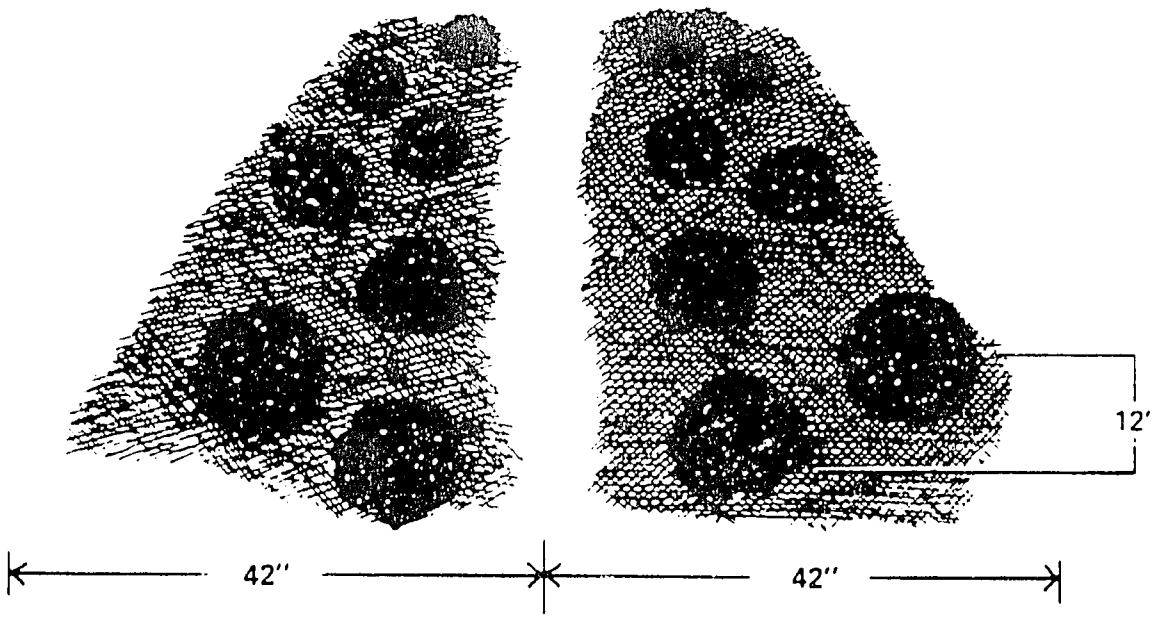


Figure 6. Strawberry plant spacing for West Texas spring (annual) planting system.

The planting date is from mid-August through early September.

Sprinkler irrigation is essential the first few weeks following planting.

Summer-planted strawberries will require additional after-care. One or two fruit clusters will form in September and should be removed. Runners also will form and should be removed. This may mean three or four pruning operations. This flower and runner pruning will force a large proportion of the manufactured food into the development of a thick-heavy crown.

WEST TEXAS

Spring (Annual) Planting System

Home growers in areas west of Fort Worth and San Antonio can successfully grow the Everbearing strawberry on a hill system.

The main crop will be harvested one year following planting. Allow the mulch to remain between the plants during this period. The runners which are produced should be removed to maintain a strong plant.

VARIETIES

The strawberry is rather sensitive to its cultural requirements. Most varieties, having been developed in the Northeast, are not heat resistant. Some are too late, some produce a stunted plant and some produce runners instead of a crop of fruit. Others seem to lack the high quality attributed to them when grown under other conditions. Over the years, several varieties have done well under Texas conditions. Each of these varieties is described by areas.

East Texas

1. *Sunrise* is a USDA released variety and shows extreme durability to adverse Texas conditions. It is an early berry, which makes it susceptible to frost damage. It is resistant to red stele, verticillium wilt and some foliage diseases. The fruit is light red and tends to run somewhat small.

2. *Pocahontas* was developed and released in Maryland in 1946. It is a large firm berry with sub-acid (tart) flavor and good freezing quality. It is resistant to leaf diseases and is a good runner producer. It is susceptible to verticillium wilt and red stele.

3. *Dixieland*, a 1953 USDA release, was grown extensively throughout Texas several years ago. However, because of a physiological disorder known as "Yellows," it has dropped in popularity. When healthy, it is productive and bears early, firm, attractive berries.

4. *Blakemore*, a 1923 USDA variety, has been the North Texas standard for many years. Because of low yield, it has given way to newer varieties in recent years. It bears light red, small, firm berries which have an acid (tart) flavor. The plants are vigorous and heat resistant. As a home garden variety, it is also resistant to diseases and desirable for preserving.

South Texas

1. *Fresno* is a California variety released in 1955. It produces a large firm bright red strawberry. Fresno does exceptionally well in South Texas, especially when summer planted.

2. *Florida Ninety* was developed in Florida and released in 1947. Large, long berries are produced early. They have a high dessert flavor, but are less firm than desirable. This variety is susceptible to leaf diseases. The plants are productive and produce more runners than any other variety.

3. *Dabreak* was developed in Louisiana and released in 1961. Limited summer planting trials in South Texas have suggested that this may be the variety of the future. It is a leading variety in Florida and Louisiana. The fruit is bright red, large, smooth and firm with excellent taste. Runner production is medium to good. The Dabreak is resistant to leaf spot diseases, but highly susceptible to crown rot.

4. *Tioga*, *Salinas* and *Solana* are California strawberries that can be used in South Texas. Results with these varieties have not been consistent over the years. The California varieties show susceptibility to leaf spot diseases.

5. *Sequoia*, also a California strawberry, is of exceptional quality, size and color. Sequoia has made high yields in South Texas. Unfortunately, it is very soft and cannot be shipped or marketed commercially. Sequoia is an excellent garden variety.

West Texas — Everbearing Varieties

1. *Gem* (Superfection) was developed in Michigan in 1933. Berries are soft, small and irregular in shape. The fruit is a glossy deep red with a pale red center. It has an acid taste and good dessert quality. Gem is susceptible to leaf diseases.

2. *Ozark Beauty* was introduced in Arkansas in 1955. It produces a large, sweet, good-flavored berry. Mother plants are productive, but runner plants usually produce no berries.

3. *Ogallala* was introduced by USDA workers in Wyoming in 1958. It produces medium to large high-flavored fruit. The plants are very hardy and resistant to leaf spots.

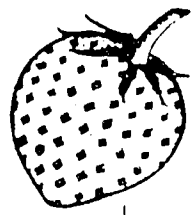
SPECIAL STRAWBERRY BEDS

Strawberries can be grown in special beds where space is limited or the soil is not optimum for normal plantings. In addition to fresh berries, strawberry beds offer year-round greenery and white spring flowers. Redwood or cedar beds can be used as borders along walkways, ground covers or pyramids, figure 7.

Urban homeowners often lack sufficient space for gardening or standard strawberry culture. In these situations, a wooden strawberry bed utilizes very little space and offers an attractive accent to the landscape.

Since all soils of Texas are not adapted to strawberries, special beds can be filled with a soil mix. An optimum medium can be prepared by thoroughly mixing one-half part coarse builders sand, one-fourth part finely ground sphagnum peat moss, and one-fourth part top soil. Should sphagnum peat moss not be available, other sources of organic matter such as standard peat, saw dust, ground pine bark, decomposed barnyard manure or leaf compost could be used.

Special beds should be built so that there are at least 10 inches of soil mix. This would allow good root development, high water-holding capacity and sufficient internal drainage.



SUMMARY

1. Purchase disease and salt-free plants of the proper variety.
   a. West Texas
      1. Ogallala
      2. Gem
      3. Ozark Beauty
   b. East Texas
      1. Sunrise
      2. Pocahontas
      3. Dixieland
      4. Blakemore for home gardens
   c. South Texas
      1. Fresno
      2. Florida Ninety
      3. Dabreak
      4. California varieties
      5. Sequoia for home gardens
2. Use the proper planting system:
   a. West Texas – Annual Spring Hill
   b. East Texas – Biennial Spring Matted Row
   c. South Texas – Annual Summer or Fall Hill
3. Plant at the proper depth – mid-crown.
4. Irrigate when needed – as leaves begin to wilt.
5. Fertilize with 800 pounds per acre of 6-12-6.
6. Control insects, nematodes and diseases.
7. Mulch to control weeds, conserve moisture, maintain clean fruit and protect against frosts. Use straw in East and West Texas and polyethylene in South Texas.

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DISEASES, NEMATODES, MITES, AND INSECTS AFFECTING STRAWBERRIES IN FLORIDA

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INTRODUCTION

Strawberry plants are grown in all months of the year in Florida—in plant nurseries during the winter, spring, summer, and early fall, and in fruit production fields in the fall, winter, and spring. The warm, humid climate of the state that permits year-round growth of plants in the field is also ideal for the development of a large number of diseases and pests on the crop as environmental conditions become favorable for their activity. Growers must be concerned about growing disease-and pest-free plants that will be used for fruit production or for establishing new nurseries.

This bulletin offers causes, symptoms, and control measures for strawberry diseases and pests that are important in Florida. Since control recommendations may change frequently, specific recommendations are not listed. Consult extension or research personnel or publications for current control recommendations.

DISEASES

Although several organisms attack more than one part of the plant, the diseases are divided into the following groups: 1) Crown and Root Diseases; 2) Leaf Diseases; 3) Fruit and Flower Diseases; 4) Virus Diseases; and 5) Noninfectious Diseases.

CROWN AND ROOT DISEASES

DISEASE.—Anthracnose

CAUSE.—*Colletotrichum fragariae* Brooks
Glomerella cingulata (Ston.) Spauld. & Schrenk

SYMPTOMS.—The first symptom of anthracnose usually is the formation of very small, black, sunken lesions on the youngest runners. (Occasionally black leaf spot, described under "Leaf Diseases," is the first symptom noticed.) Lesions on the runners enlarge and coalesce to form long, black, dry, sunken areas up to an inch (2.54 cm) or more long (Fig. 1). These often girdle the runner, resulting in death of unrooted daughter plants beyond the lesion. The black, sunken lesions also occur on leaf stems, especially on highly susceptible cultivars. Infected stems often bend downward sharply at the point of the lesion, causing the leaves to hang downward (Fig. 2). The fungus also can infect the crowns of plants. If this occurs early

enough, infected plants wilt and die suddenly in the nursery. These plants later turn back and appear as if they had been burned by fire.

When infected plants are set into the fruit production field, individual plants wilt and die at any time during the fruiting season. A cut lengthwise through the crowns of freshly wilted plants reveals streaks or large areas of reddish-brown, firm tissue.

DISEASE DEVELOPMENT.—Anthracnose is most important in summer plant production beds. The disease is favored by high temperatures, moisture and high fertility. After initial infection, spores are formed abundantly on developing lesions. These spores blow and splash to other plants and initiate new infections. Crown infections occur when the fungus grows into the crown from lesions on runners or leaf stems, or when spores that are washed into the bud germinate and infect the crown directly.

In the fruit production field, *C. fragariae* usually causes a fast wilt, with individual plants completely wilting within a few days after the first sign of wilt. Wilting is most severe during periods of warm weather. Slow wilting occasionally can be found during periods of cool weather (below about 60°F (15°C). In these cases, the oldest leaves begin to dry and turn nearly black. If temperatures remain low, the symptoms occur on successively younger leaves until the entire plant is affected within about two weeks. These symptoms somewhat resemble fertilizer burn, but unlike plants affected by fertilizer burn, those affected by *C. fragariae* do not recover regardless of how much overhead irrigation is applied.

CONTROL.—Apparently all, or nearly all, infection by *C. fragariae* occurs in the summer nursery with little or no spread in the fruit production field. Therefore, excellent control of anthracnose in the summer nursery will also prevent wilt in the fruit production field.

Anthracnose can be controlled by the use of resistant cultivars. If susceptible cultivars are used, they should be set in the summer nursery no earlier than June, soil fertility should be kept at a low level through July and August, foliar fertilizers should never be used, and approved fungicides should be applied every two days from late June at least through mid-September. If heavy or frequent rains continue through mid-September, fungicide applications should continue at 2-day intervals through the end of September. Spray intervals then may be extended to 3 or 4 days until the plants are dug.

DISEASE.—Bud Rot

CAUSE.—*Rhizoctonia* spp.

SYMPTOMS.—When strawberry plants with a single-bud crown are attacked in the fruit production field, the bud is killed by dry-rot and may be pulled easily from the remainder of the plant. When the bases of the older leaf stems are attacked, they become dry-rotted, and the leaves lie flat on the plastic mulch. They may continue to grow in this position and live out their normal life span. Death of the main bud results in death of the plant unless lateral buds subsequently develop and are not themselves attacked by the fungus.

The fungus attacks flower buds in any stage of development. When the early forms are attacked, the buds develop dry rot and die. When an open or nearly open bud is attacked, a large purple or black lesion forms on the calyx, and the center of the blossom becomes black (similar in appearance to freeze damage).

In the nursery, Rhizoctonia may cause a wet, slimy rot of leaf buds and stems or dry rot of the bases of the petioles (Fig. 3) and of the buds.

DISEASE DEVELOPMENT.—*Rhizotonia solani* Kuhn is generally considered to be the cause of bud rot; however, other species of *Rhizoctonia* also may be involved. *Rhizoctonia* species are widely distributed in Florida soils and cause diseases of many species of plants. The *Rhizoctonia* species that causes bud rot is favored by high moisture conditions.

Bud rot becomes a problem in the nursery only where plants are very crowded or in wet areas of the field where drainage is poor. One of the major causes of vegetative bud rot is plants being set too deeply in either the nursery or fruit production field. Any time a portion of the central bud is covered by soil, bud rot is likely to occur.

In established fruit production plantings, bud rot is favored by high humidity and wet soil caused by extended periods of rainy or foggy weather and heavy dews which keep the plants wet for long periods. Large plants or plants set too closely together on the bed tend to hold a moist atmosphere around the buds and thus favor the disease.

CONTROL.—Every possible precaution should be taken to insure that the plants are not set too deeply in the nursery or fruit production field. Plants should be spaced widely enough on the beds in the fruit production field to allow air circulation which will facilitate drying of foilage and buds after the plants have grown. Within 3 to 4 weeks after the plants are established, approved fungicides should be applied at 3 to 4-day intervals.

Only sites with excellent drainage should be chosen for nursery areas. Ditching around the nursery should be done if necessary to improve drainage, and plants should be set widely enough that overcrowding will not occur as runners are produced.

DISEASE.—Root Rot

CAUSE.—*Rhizoctonia fragariae* Husain and McKeen

SYMPTOMS.—Dark brown lesions up to an inch (2.54 cm) long

form on infected roots and the entire root system may be attacked and turn brown. Severely infected plants cease growing and remain stunted in relation to surrounding healthy plants. They may die very slowly, or if good drainage is supplied, they may recover.

DISEASE DEVELOPMENT.—Root rot occurs in both the nursery and the fruit production field. The major cause of the disease is poor soil drainage. It usually occurs only in wet areas where the soil remains saturated for extended periods after rains or irrigation.

CONTROL.—Root rot can be controlled by ditching around poorly drained fields to improve drainage. Very poorly drained areas should be avoided for fruit or nursery production.

DISEASE.—Southern Blight

CAUSE.—*Sclerotium rolfsii* Sacc.

SYMPTOMS.—*Sclerotium rolfsii* causes a wet rot of crowns, leaf stems, and buds in the nursery. Web-like, white mycelium of the fungus usually can be found growing profusely over the infected crowns and surrounding soil. Small, hard sclerotia (resting bodies of the fungus) are usually found scattered through the mycelium. The sclerotia are about the size of large strawberry seeds. They are white at first, then tan, and eventually dark brown.

When *S. rolfsii* attacks plants in October or November soon after they have become established in the fruit production field, it causes dry rot of the young leaves, the central bud, and some or all of the emerging flower buds. The affected leaves and buds die and become light tan in color. The large outer leaves usually remain green for a few weeks, but lie flat on the plastic because of infection of the bases of their stems. Sclerotia (Fig. 4) usually can be found on the dead central bud, or on the bases of the stems of the dead young leaves.

When *S. rolfsii* attacks plants in the fruit production field during the spring, it causes dry rot of crowns, leaf stems, and buds of individual plants. The plants then wilt and die slowly. Mycelium and sclerotia may or may not be found on the crowns of these plants.

DISEASE DEVELOPMENT.—Southern blight is favored by hot, wet weather. It seldom becomes a major problem in strawberries. In the nursery, it is usually limited to individual plants or a few plants in areas 1 to 2 feet (30.48 to 60.96 cm) in diameter.

Southern blight usually does not occur in fruit production fields until mid-April or May near or after termination of commercial harvest. Thus, losses are minimal even though many plants may be killed at that time.

CONTROL.—Southern blight is widely distributed in Florida and affects a wide range of plants. Specific control measures on strawberries have not been determined.

DISEASE.—Verticillium Wilt

CAUSE.—*Verticillium albo-atrum* Reinke and Berth

SYMPTOMS.—Verticillium wilt is first noticed as older leaves on individual plants begin to wilt. The margins of the leaflets on these leaves then turn brown or nearly black along the edges. The younger leaves remain light green, usually with yellow margins around the edges of individual leaflets, and often become slightly wilted. As wilt progresses, successively younger leaves turn brown to nearly black. Plants wilt slowly, and infected plants may survive in a stunted, partially wilted stage (Fig. 5) for three months or longer. Plants that survive until spring often recover and appear to grow normally.

DISEASE DEVELOPMENT.—The *Verticillium* fungus is widely distributed in the highly calcarious soils of south Florida and is a serious problem there. It apparently does not occur naturally in soils in the central and north Florida strawberry production areas. It becomes a problem in these two areas only when infected plants from other states are set in the fields.

CONTROL.—In infested soils, adequate control of Verticillium wilt is obtained by preplant treatment with soil fumigants approved for control of this disease. Growers in central and north Florida should make every effort to avoid setting infected plants in order to prevent introduction of the fungus into those areas.

DISEASE.—Black Root

CAUSE.—Varies

SYMPTOMS.—Roots of plants dug from the nursery are dark brown or black and appear dead.

DISEASE DEVELOPMENT.—Black root in Florida usually appears to be caused by physiologic factors rather than by pathogenic organisms. When plants from a winter nursery are allowed to grow through the summer, or when summer nurseries are established early and the beds become full of plants by mid-August, their roots often will be black when they are dug in October.

Water standing for long periods around plants in the nursery will also cause black root. In this case, blackening of the roots is probably caused by a combination of microorganisms and lack of oxygen in the soil.

CONTROL.—Black-rooted plants can usually be induced to form new white roots by running a blade under them about six inches (15.24 cm) deep two or three weeks before digging. This is seldom needed, though, because even without this treatment they usually grow normally after transplanting. When plants become black rooted because of water standing in spots in the nursery, most of them will form new white roots after natural drainage occurs. Recovery can be

hastened by ditching or cultivation to allow the soil to dry more rapidly.

LEAF DISEASES

There are several important leaf diseases of the strawberry in Florida. Some of them can be serious at any time of year. Others are serious only in the winter or only in the summer nursery. Control measures for leaf diseases are presented at the end of this section.

DISEASE.—Common Leaf Spot

CAUSE.—*Mycosphaerella fragariae* (Tul.) Lindau

SYMPTOMS.—Spots are small at first, less than 1/8 inch (3.2 mm) in diameter, and are purplish red. They increase in diameter to about 3/16 inch (4.8 mm) on most cultivars and up to 3/8 inch (9.5 mm) on some. The spots remain nearly circular with purple borders and white or gray centers (Fig. 6). Spots number from one to many on each leaflet and, if extremely numerous, cause death of the leaflet. If many leaflets die, the plant itself may die or be stunted.

DISEASE DEVELOPMENT.—Common leaf spot is favored by warm, wet weather but it can become serious at any time of year. Under favorable conditions the fungus sporulates profusely on the undersurfaces of the spots. The spores are blown or splashed to other leaflets and initiate new infections.

In rare instances, when spores are plentiful from old infections and weather conditions are extremely favorable, common leaf spot is manifested in an unusual manner. In these cases many tan spots lacking purple borders appear during a period of two or three days and large portions of leaflets die and turn light tan. On the undersurface of the leaflets, the spots appear water-soaked when the leaves are wet and closely resemble angular (bacterial) leaf spot. This seems to occur only after periods of warm, rainy weather followed by two or three days of foggy mornings and heavy dews. Symptoms differ from those of angular leaf spot in that no whitish bacterial ooze is found on the water soaked spots, and as the leaves dry, the spots dry to a light tan and are not covered by the slick, shiny bacterial deposit that occurs with angular leaf spot. Purple borders form around the individual spots after about a week.

DISEASE.—Leaf Blight

CAUSE.—*Dendrophoma obscurans* (Ell. & Ev.) Anderson

SYMPTOMS.—Young spots of this disease are often difficult to distinguish from those caused by common leaf spot. They are round, purple, and have gray centers. As the spots enlarge, the central zone becomes dark brown, surrounded by a lighter brown zone which in turn is bordered by a purple, red, or yellow zone which blends into the normal green of the leaf. Mature spots are usually V-shaped with the wide part of the V at the edge of the leaflet (Fig. 7). Small black dots, the fruiting structures of the fungus, appear in the central, dark brown zones of the spots.

DISEASE DEVELOPMENT.—Leaf blight is favored by warm, wet weather but may become severe at any time of year.

DISEASE.—Leaf Scorch

CAUSE.—*Diplocarpon earliana* (Ell. & Ev.) Wolf

SYMPTOMS.—Spots first appear on the upper surfaces of leaflets as small purplish discolorations which enlarge into irregular purple or red blotches from 1/16 to 3/16 inch (1.6 to 4.8 mm) in diameter. In these spots are very small, black, glistening bodies which are the fruiting structures of the fungus. The spots on some leaflets may become so numerous that they coalesce and give a dark reddish cast to the entire leaflet (Fig. 8). In cases of severe infections, the edges of the leaflets curl upward and the tissue dies and dries to a tan color, progressively from edge to midrib, giving the plant a scorched appearance.

DISEASE DEVELOPMENT.—Leaf scorch can appear at any time of year.

DISEASE.—Leaf Blotch

CAUSE.—*Gnomonia comari* Harsten

SYMPTOMS.—Leaf blotch lesions begin as small, circular, tan spots and rapidly enlarge to an inch (2.54 cm) or more in diameter. The lesions usually remain round, but occasionally become V-shaped and resemble leaf blight lesions. However, blotch lesions remain lighter tan and are not surrounded by colored borders (Fig. 9). Small, black fruiting bodies appear in concentric circles within the blotch lesions. One or two lesions on a leaflet will often enlarge to encompass the entire leaflet within four or five days. Killing of leaflets in this manner sometimes causes rapid defoliation of entire plants.

DISEASE DEVELOPMENT.—This disease is usually found only during late fall and early winter on plants shipped into Florida from other states. It has been found occasionally in mid to late winter but has not been detected in the summer nursery.

DISEASE.—Powdery Mildew

CAUSE.—*Sphaerotheca macularis* (Wallr. ex Fries) W. B. Cooke

SYMPTOMS.—A sparce, white, web-like growth covers small areas of the undersurfaces of leaflets in the early stage of this disease

(Fig. 10). Tiny, nearly transparent spores produced on the growth give a powdery appearance to these spots. As the disease becomes more severe, more leaflets become infected, and the web-like growth spreads until it covers nearly the entire undersurface of some leaflets. Irregular-shaped yellow or black spots up to ⅜ inch (8.5 mm) in diameter often form on the upper surfaces of leaves that have been infected for some time. The edges of the leaflets curl upward (Fig. 11) as infection continues and the entire field (or sections of the field) may have a silvery appearance because of the exposure of the fungus growth on the undersides of the leaflets.

At times, specialized fruiting structures (the cleistothecia) of the fungus can be found scattered through the weblike growth. These are white at first and gradually turn black.

DISEASE DEVELOPMENT.—Powdery mildew is favored by cool, moist conditions and may become a serious problem any time from November through February.

DISEASE.—Angular Leaf Spot

CAUSE.—*Xanthomonas fragariae* Kennedy & King

SYMPTOMS.—Lesions begin as small, irregular, water-soaked areas on the undersurfaces of leaflets (Fig. 12). When moisture is plentiful on the leaflets, especially in the morning, whitish, sticky droplets of bacterial ooze occur on the water-soaked spots on the undersides of the leaflets. As the moisture dries, the droplets of bacteria also dry and form a slick, shiny covering over the lesions. At this stage, the undersides of infected leaflets appear as if clear lacquer had been dabbed on them. As the spots enlarge and become more numerous, corresponding yellow, dark green, or red areas appear on the upper surfaces of the leaflets. In severe cases entire leaflets are killed and turn light brown. Plants may be defoliated except for a few very young leaves in the centers of the crowns.

DISEASE DEVELOPMENT.—Angular leaf spot is the only strawberry disease in Florida caused by a bacterium. It is favored by cold weather and becomes especially severe during and after periods of frequent night-time freezes coupled with low day-time temperatures. With the advent of continuing warm weather in the spring, even severely defoliated plants produce new leaves which, at worst, may become lightly infected. By mid-April it is often difficult to find any signs of the disease. Angular leaf spot is never a problem in the summer nursery, although a low incidence of the disease sometimes occurs there.

DISEASE.—Black Leaf Spot

CAUSE.—*Colletotrichum fragariae* Brooks
Glomerella cingulata (Ston.) Spauld. & Schrenk

SYMPTOMS.—Spots first appear as tiny black dots less than 1/16 inch (1.6 mm) in diameter. They enlarge to 1/16 to ⅛ inch (1.6 to 3.2 mm) in diameter and remain black (Fig. 13). Although many spots may be present on individual leaflets, they do not cause death of the leaflets.

DISEASE DEVELOPMENT.—Black leaf spot is caused by the same fungus that causes anthracnose. It occurs any time from June through mid-September in the summer nursery, and in late April and May in the winter nursery. Black leaf spot usually appears only after anthracnose has become moderate to severe on runners and leaf stems. At times, however, black leaf spot appears first and is the first indication that the anthracnose fungus is present. At the first sign of black leaf spot, approved fungicides should be applied on a 2-day schedule and after every rain and every irrigation to minimize anthracnose.

DISEASE.—Web Blight

CAUSE.—*Rhizoctonia solani* Kuhn

SYMPTOMS.—Web blight is of minor importance in Florida. The fungus grows over the lower surfaces of leaves and causes death of some leaves. Close examination reveals the web-like growth of the fungus on infected leaves.

DISEASE DEVELOPMENT.—Web blight is favored by high moisture levels and crowding of plants. It occurs most frequently in the summer nursery during periods of frequent irrigation or rainfall after plants have become crowded. It is found occasionally in fruit production fields when plants become very large and crowded.

DISEASE.—Vein Infection

CAUSE.—*Rhizoctonia* spp.

SYMPTOMS.—Vein infection is another disease of minor importance in Florida. In this case the *Rhizoctonia* fungus infects the lower surfaces of main veins. This retards or stops growth of the vein in the infected area and causes the leaflets to curl downward or to pucker.

DISEASE DEVELOPMENT.—Vein infection is favored by high moisture levels and crowding of plants. It occurs most frequently in the summer nursery during periods of frequent irrigation or rainfall after plants have become crowded. It is found occasionally in fruit production fields when plants become very large and crowded.

CONTROL OF LEAF DISEASES.—Excellent control of all the strawberry leaf diseases except angular leaf spot and black leaf spot can be obtained by applications of approved fungicides at 3- to 4-day intervals in fruit production fields and nurseries.

Angular leaf spot is caused by a bacterium, and most fungicides are ineffective for its control. At the present time, copper fungicides are the only ones known to give some control of angular leaf spot. Copper becomes toxic to strawberry plants, though, after a few applications and should not be applied more than four or five times during any 2-month period. Since that number of applications will not give noticeable control, especially during extended periods of cold weather, it is questionable whether attempts to control angular leaf spot are worthwhile.

To control black leaf spot, approved fungicides should be applied every two days and after every rain or application of irrigation from early July through early September. Soil fertility levels also should be kept low through August because high fertility appears to increase susceptibility to black leaf spot and anthracnose.

FRUIT AND FLOWER DISEASES

Fruit rots may occur in the field before harvest or at any time after harvest until the fruit is consumed. When infection of fruit occurs shortly before harvest, rot often will not develop until after harvest. Thus it is essential to cool the fruit to 33° to 35°F (0.5 to 1.6°C) as quickly as possible after harvest to retard growth of the fungi that cause rots. Control measures for fruit diseases are presented at the end of this section.

DISEASE.—Gray Mold or Brown Rot

CAUSE.—*Botrytis cinerea* Pers.

SYMPTOMS.—Infected areas on fruits are light brown at first, then become dark brown. The flesh in the infected areas is slightly soft at first, then becomes hard and dry. There is no distinct line of demarcation between diseased and healthy tissue. Under moist conditions, infected fruits are covered with gray, dusty spores of the fungus (Figs. 14, 15).

DISEASE DEVELOPMENT.—Gray mold becomes most serious during periods of prolonged wet weather. Under moist conditions the fungus may attack strawberries in all stages of development from blossom bud stage to fully ripe. The spores that are formed on buds, flowers, and fruit blow around readily and initiate new infections.

DISEASE.—Colletotrichum Rot

CAUSE.—*Colletotrichum fragariae* Brooks
Glomerella cingulata (Ston.) Spauld. & Schrenk

SYMPTOMS.—Rotting spots on ripe fruit are round, sunken, firm, light brown to black, and vary from ⅛ to ½ inch (3.2 to 12.7 mm) or more in diameter (Fig. 16). Salmon-colored masses of spores often can be seen on the spots. Two or more spots sometimes coalesce.

Spots on green fruits are hard, dark brown or black, sunken, and usually 1/16 to ⅛ inch (1.6 to 3.2 mm) in diameter. As the infected green fruits enlarge, the spots usually remain small and become progressively more sunken. Red or purple borders often form around the infected spots as the fruits mature to the white stage. As the infected fruits ripen, the spots enlarge rapidly and form the typical ripe fruit rot as described above. The spots sometimes enlarge on the green fruits. It is then often impossible to distinguish this rot from Rhizoctonia rot with the unaided eye. Inspection of such lesions with a dissecting microscope usually reveals small, crusty spore masses in cases of Colletotrichum rot.

Flower blight (Fig. 17) occurs when the flower, or the fruit stem immediately below the flower, becomes infected. The center of the flower turns black, and the calyx (the cap) and a portion of the stem becomes tan or light brown and dry. Sticky, gelatinous masses often form on infected flower stems. These masses are apparently sap exuded from the plant, but *Colletotrichum* spores are sometimes present in them. Stem lesions may extend 2 to 3 inches (5 to 7.6 cm) below the flowers.

DISEASE DEVELOPMENT.—This rot is caused by the same fungus that causes anthracnose. It becomes serious only during warm or hot weather. Colletotrichum rot is extremely difficult to control once it has reached moderate levels in a field. It is primarily a rot of ripe fruit, but when disease incidence reaches a high level, it also affects green fruit. A few fields have been seen in which one or more lesions were present on nearly every green fruit.

To date flower blight has been seen only on the Pajaro variety. It has been very severe in some fields of Pajaro, with nearly all blossoms of a particular flush being affected. Flower blight is favored by warm, rainy weather.

DISEASE.—Dendrophoma Rot

CAUSE.—*Dendrophoma obscurans* (Ell. & Ev.) Anderson

SYMPTOMS.—In early stages rot appears as round, light pink, water soaked, nonsunken spots. Two or more lesions often coalesce. Infected areas later turn light brown (Fig. 18), and the entire fruit is

invaded and becomes soft. Infected fruits eventually mummify and sometimes appear black after numerous pycnidia (fruiting structures of the fungus) develop

DISEASE DEVELOPMENT.—Dendrophoma rot is caused by the same fungus that causes leaf blight. It is favored by warm weather, but occasionally becomes serious during cool weather. Dendrophoma rot is primarily a disease of ripe fruit but is found on green fruit when disease incidence reaches a high level. Dendrophoma rot, like colletotrichum rot, is one of the most difficult of diseases to control when rot levels reach a moderate or severe degree.

DISEASE.—Leaks or Whiskers

CAUSE.—*Rhizopus stolonifer* Ehrenb. ex Fr.

SYMPTOMS.—In the field, fruits in the early stages of infection often appear healthy from above, but when an attempt is made to pick them, the part of the fruit in contact with the plastic mulch is found to be very soft and mushy. Infected fruits lose juice rapidly and collapse into a mushy mass. A blueish growth occurs on the collapsed fruits as the fungus sporulates. Infected fruits often can be found easily in the field by looking for juice trails on the plastic mulch down the sides of the beds.

Rot that develops after harvest causes collapse of the fruit tissue and rapid loss of juice, which drips out of the container, thus giving rise to the common name "leaks." A loose cottony growth of the fungus may appear over the surface of the fruit. This is the "whiskers" stage. This growth takes on a blue color when the spore bearing structures of the fungus form on the white mycelium, or "whiskers," of the fungus (Fig. 19).

DISEASE DEVELOPMENT.—This rot is favored by hot, moist conditions. It is of most importance during transportation and marketing. Generally it is found in the field only on overripe fruits. It usually does not become serious in the field until after overripe fruit has accumulated because of an interruption of the picking schedule.

DISEASE.—Hard Brown Rot

CAUSE.—*Rhizoctonia solani* Kuhn

SYMPTOMS.—Hard brown rot may occur on blossoms and fruit in all stages of development, but it is most often noticed on green fruit. The infected parts of green fruit are light brown at first. These areas later turn dark brown to almost black and become hard and dry (Fig. 20). Often only the tip of the fruit is invaded, and affected fruit closely resemble freeze-damaged fruit. In some cases the entire fruit or the stem end of the fruit is attacked, and a large purplish lesion forms on the green calyx. When developing flower buds are attacked, large purplish lesions form on the calyces and may extend an inch (2.54 cm) or more down the flower stems (Fig. 21).

DISEASE DEVELOPMENT.—Hard brown rot is caused by the same fungus that causes bud rot. It is favored by warm, moist weather conditions and becomes especially severe during periods of foggy weather.

DISEASE.—White Rot

CAUSE.—Unidentified Fungus

SYMPTOMS.—Rot appears as a large, soft, white or very light purplish area on the ripe fruit (Fig. 22). The entire fruit is invaded and becomes soft within two or three days after infection is first noticed.

DISEASE DEVELOPMENT.—White rot is caused by a fungus which has not yet been identified but is probably a species of *Rhizoctonia*. Only ripe fruits appear to be attacked. The disease is erratic in occurrence, seeming to appear suddenly in a particular field, then disappear almost as suddenly.

DISEASE.—Alternaria Rot

CAUSE.—*Alternaria tenuissima* (Fries) Wiltshire

SYMPTOMS.—In early stages of Alternaria rot, lesions are irregular in shape and slightly sunken. A light green color develops on the lesions as the fungus begins to sporulate. Advanced lesions are circular, sunken, firm, and dark green to almost black because of abundant sporulation by the fungus (Fig. 23).

DISEASE DEVELOPMENT.—This rot may occur at any time during the fruiting season. Although it is not one of the more serious strawberry diseases, it does become quite severe at times in some fields.

DISEASE.—Stem-End Rot

CAUSE.—*Gnomonia comari* Karsten

SYMPTOMS.—Stem-end rot is characterized by light brown discoloration of the fruit, usually at the stem end. When small green fruits become infected, irregular brown areas appear on them, and the fruits dry and fail to develop further. Large green fruits begin to ripen prematurely, and turn pale red and brownish. Ripe fruits develop areas of soft rot. Infection often appears to start under the calyx (cap) and to spread outward from there (Fig. 24).

DISEASE DEVELOPMENT.—This rot is caused by the same fungus that causes leaf blotch. It is usually seen only on ripe fruit in

Florida. Stem-end rot is noticed only occasionally in Florida but can become severe in individual fields in which leaf blotch reaches moderate to severe levels. Stem-end rot is favored by wet conditions.

DISEASE.—Pestalotia Rot

CAUSE.—*Pestalotia longisetula* Guba

SYMPTOMS.—In early stages, lesions are 1/16 to 1/8 inch (1.6 to 3.2 mm) in diameter, dry, light tan, slightly sunken, and often irregular in shape. As rot progresses, the central area enlarges and becomes nearly circular but remains dry, light tan, and only slightly sunken below the original surface of the fruit. A circular band of tissue around this central area usually becomes soft and definitely sunken (Fig. 25). The entire fruit is eventually affected and mummifies. At times the central area enlarges until most of the infected fruit is dry and light tan. With this type lesion, no soft rot band develops. Occasionally, white mycelium of the fungus develops on infected fruits, and droplets of liquid containing spores are scattered over the mycelium. In a third variation of symptoms, numerous fruiting structures of the fungus form in the lesion, and part or all of the infected fruit appears black.

DISEASE DEVELOPMENT.—This rot occurs only rarely in Florida. Conditions that favor its development have not been determined.

DISEASE.—Leather Rot

CAUSE.—*Phytophthora cactorum* (Leb. & Cohn.) Schroet

SYMPTOMS.—Leather rot occurs on green or ripe fruits as dark brown, dry, leathery areas. On partially colored fruit there may be a purple border around the brown lesion. If a diseased fruit is cut through the lesion, there is no clear line separating diseased and healthy tissue, but the water conducting system leading to each seed is dark in color. Leather rot seldom becomes a serious problem in Florida.

DISEASE.—Light Tan Rot

CAUSE.—*Dischohainesia oenotherae* (Cke. & Ell.) Nannf.

SYMPTOMS.—Spots produced on the fruit are small, sunken, and tan. They increase in size very slowly. The infected tissue forms a corky, cone-shaped core which can be removed intact from the surrounding healthy tissue.

DISEASE DEVELOPMENT.—This rot occurs only rarely in Florida. Conditions favorable for its development have not been determined.

DISEASE.—Powdery Mildew

CAUSE.—*Sphaerotheca macularis* (Wallr. ex Fries) Jacz.

SYMPTOMS.—Infected green fruits become bronze or brownish, and a network of very fine, shallow cracks develop in the surfaces of these fruits (Fig. 26). These symptoms often are mistaken for spray burn. As the fruits ripen, the cracks widen, and the fruits become reddish brown or rusty colored and have a dry appearance.

DISEASE DEVELOPMENT.—Powdery mildew is normally a leaf disease, but it sometimes also affects the fruit. Powdery mildew is favored by cool, moist conditions and should be controlled as quickly as possible after it is found on the foilage in order to prevent fruit damage.

DISEASE.—Anther and Pistil Blight

CAUSE.—*Rhizoctonia fragariae* Husain and McKeen

SYMPTOMS.—This disease exhibits a wide range of severity. In some flowers, some or all of the anthers are destroyed and appear dark brown when the flowers open. With more severe infection, some of the pistils are also attacked. When these flowers first open, the anthers are dark brown, and a portion of the center (or pistilate area) of the particular flower appears smooth and devoid of pistils. In still other flowers, all anthers and pistils are destroyed before the buds open. The entire centers of these flowers are black (Fig. 27) and resemble freeze damage.

DISEASE DEVELOPMENT.—Infection occurs before or shortly after flower buds emerge from the crown and ceases soon after the buds open. Destruction of the anthers results in destruction of pollen; however, flowers in which only anther destruction occurs can produce normal fruit after fertilization by pollen from healthy flowers. Flowers with pistil damage produce fruit with varying degrees of deformity depending on the number of pistils that are destroyed. The presence of deformed fruit is not diagnostic of this disease because many other factors also cause fruit deformity.

Buds in which pistil damage has occurred can usually be detected a few days before they open. As these buds swell and the petals become visible, tan lesions can be found on the petals, or much of the visible petal area has a pink color. The causal fungus can be isolated readily from unopened buds, but only rarely from infected flowers after they have opened.

DISEASE.—Brown Cap

CAUSE.—Varies

SYMPTOMS.—When the green calyx (or cap) of a fruit is killed by any agent, it becomes dry, shriveled, and unattractive (Fig. 28).

DISEASE DEVELOPMENT.—Brown cap is not a fruit rot, but it is listed here because it affects the marketability of the fruit. All the organisms which cause leaf spot and many of those which cause fruit rots can cause brown cap. In addition to these, undetermined environmental conditions can cause death of the caps and subsequent development of brown cap.

CONTROL OF FRUIT DISEASES.—Every effort should be made to prevent fruit diseases rather than to try to control them after they occur. Applications of approved fungicides at 3- or 4-day intervals beginning at the time flower buds are first seen and continuing throughout the season will usually prevent most fruit diseases from becoming serious. It is especially important to adhere as nearly as possible to the spray schedule during rainy or foggy weather.

Colletotrichum and Dendrophoma fruit rots are primarily diseases of ripe fruit, although they will affect green fruit in severe cases. Thus, a schedule of short harvest intervals (3 or 4 days) to prevent a build up of overripe fruit in the field is a valuable aid in controlling these rots. These rots are extremely difficult to control if they reach moderate or severe levels. At times in severe cases, it may be more practical to pick off and discard all ripe and pink fruit and then apply fungicides at 2-day intervals for 8 to 10 days rather than to try to control these two diseases by fungicides alone.

Since powdery mildew is erratic in occurrence, regular applications of fungicides effective for its control are not needed. However, fields must be inspected frequently for the disease during the fall and winter to prevent it from becoming severe before it is noticed. Fungicides that are specifically approved for control of powdery mildew should be applied as soon as the disease is noticed.

Anther and Pistil blight is favored by wet conditions. Precautions should be taken to insure that plants are not set too deeply. Plants should be spaced widely enough on the beds to allow air circulation. This will facilitate drying of foliage and buds after the plants have grown. Fungicides applied on a 3- to 4-day schedule are especially important.

Fungicides will control brown cap if it is caused by any of the fungal pathogens. If it is caused by the bacterium that causes angular leaf spot, or by weather conditions, there are no presently known means of control.

VIRUS DISEASES

There are several known virus diseases of strawberry plants, but most of them do not cause definite leaf symptoms in commercial cultivars. Viruses generally cause reduced plant vigor, reduced runner production, and reduced fruit yield, although in some cases in which plants are infected by a single virus, there is little measurable effect. Combinations of two or more viruses in the same plant cause much greater effects. Strawberry mottle virus is one of the few viruses that cause recognizable symptoms in commercial strawberry cultivars. Since strawberry mottle is the only virus disease that has definitely been found in Florida, only the mottle disease will be described in this bulletin.

DISEASE.—Mottle

CAUSE.—Strawberry Mottle Virus

SYMPTOMS.—Severely affected plants produce several to many small crown-buds. Leaves produced by these buds are small and have very short stems. Individual leaflets are slightly deformed and have yellow margins (Fig. 29). Less severely affected plants produce a single central bud. The first 2 to 5 leaves that are produced are nearly normal in size and appearance. All subsequently produced leaves are small, and the leaflets are slightly deformed and have yellow margins (Fig. 30). The root systems of plants affected by mottle virus are much smaller than are those of healthy plants.

DISEASE DEVELOPMENT.—Mottle disease is noticed only in the fruit production field in Florida. To date it has not been found in any plants that have been grown in Florida nurseries. It has been found only in plants that have been grown in other states and which were then transplanted into fruit production fields in Florida. The disease is first noticed 2 to 4 weeks after the plants have become established in the fruit production field and have begun to produce new foliage. Severely affected plants (those that produce many crown-buds) do not produce fruit at any time during the season. Less severely affected plants produce only a few very small fruits. Mottle virus apparently does not spread in fruit production fields in Florida.

Strawberry plants become infected by viruses when certain species of aphids or leaf hoppers feed on them after feeding on strawberry or other plant hosts that are infected. When a strawberry plant becomes infected by a virus, all daughter plants produced by that particular plant are also infected.

CONTROL.—The only means of controlling strawberry virus diseases is the use of plants certified virus-free. Cultivars are freed of

viruses by meristem culturing. Leaflets of each meristem-cultured plant are grafted to indicator plants which show symptoms of particular viruses that may be present. The meristem-cultured plants that index free of all known viruses are used for further propagation. During the first generations after meristeming, insecticides are applied frequently in the nursery to control the insect vectors of viruses. Whenever possible, the first generations of virus-free stocks are grown in screenhouses or in areas where the vectors do not occur.

NONINFECTIOUS DISEASES

Noninfectious diseases are those that are caused by agents other than living organisms. The causes of many of these diseases have not been determined. Although nutrient deficiencies are often considered as noninfectious diseases, they will not be covered in this bulletin.

DISEASE.—Albino Fruit

CAUSE.—Unknown

SYMPTOMS.—Fruits that are mildly affected have a slightly lighter than normal color on the shoulders near the caps (Fig. 31). These fruits are slightly softer than normal and are more easily damaged by handling during harvesting, shipping, and marketing. Moderately affected fruits are a light orange color, soft, and have poor flavor. Severely affected fruits are a very light orange color, are very soft, and taste very sour, as if they were fermented. Usually when albinism is moderate to severe, many of the fruits are catfaced (the tip fails to develop and turns black, resulting in small, knotty fruits). When a hand lens is used to inspect the light-colored area of a fruit affected by albinism, tiny, glistening, transparent structures that appear much like grains of sugar are seen under the epidermis.

DISEASE DEVELOPMENT.—The albino fruit problem can occur at any time during the harvest season, but is most likely to occur when the heavy spring flush of fruit begins to ripen in March. It is usually more prevalent and more severe in fields that have a very heavy fruit set. Albinism may occur throughout a particular field, or only in certain areas of the field. Albinism often seems to be associated with the use of excessively high rates of fertilizer.

CONTROL.—There are no definite control measures for this disease. In several cases in which albinism had been a problem for particular growers for several years, it was no longer a problem after nitrogen and potassium rates were reduced to about 200 pounds of each per acre. However, an association between albinism and excessive fertility has not been proven experimentally.

DISEASE.—Weather Burn

CAUSE.—Climatic Conditions

SYMPTOMS.—Bronze or light tan areas occur on part or all of the upper sides of ripe fruits (Fig. 32).

DISEASE DEVELOPMENT.—Weather burn generally occurs when there is a sudden change to hot weather after a prolonged period of relatively cool weather. These weather changes generally occur in March or early April. Weather burn is often mistaken for spray burn, but when it occurs, it is found in fields scattered throughout the area regardless of what pesticides are being used in any particular field. It is generally a problem for only a short time and disappears from all fields in the area at the same time.

CONTROL.—There is no known control for this disease.

DISEASE.—Sunscald

CAUSE.—Climatic Conditions

SYMPTOMS.—Large, opaque, puffy blisters that appear to be filled with fluid develop on the upper sides of fruits that are exposed to the sun. These blisters look much like burn blisters on human skin. The blisters subside within 1 or 2 days. The affected areas are then slightly sunken and water-soaked, as if they had been scalded with hot water (Fig. 33).

DISEASE DEVELOPMENT.—Sunscald occurs when the days become hot in the spring. It is usually more severe and more widespread after a sudden change from cool to hot weather. It is also more severe if the soil becomes dry enough to cause wilting of the plants. When rows are oriented east and west, sunscald is much more severe on fruits that hang over the south side of the row.

CONTROL.—Sunscald can be prevented or, at least, greatly decreased by maintaining adequate moisture levels in the beds and by using overhead irrigation during the hotter part of the afternoon. It has been thought for years that overhead irrigation during the hotter part of the day increases sunscald. However, observations at the Agricultural Research Center at Dover, Florida indicate that this decreases or prevents sunscald.

DISEASE.—Fasciation (Cockscomb)

CAUSE.—Unknown

SYMPTOMS.—In the most typical type of fasciation, large, flat fruits shaped like fans or cockscombs are formed (Fig. 34). In a less typical fasciation, fruits may have two or more points protruding outward in different directions.

DISEASE DEVELOPMENT.—Fasciation is initiated as the flower

buds begin to form within the crown of the plant when two or more flowers and stems become fused. When the flowers open, they appear to be very large single flowers on single stems, but close inspection reveals the fused stems. There is much variation in susceptibility to fasciation among cultivars. Fasciation is severe in some cultivars during some years but practically never present in other cultivars.

CONTROL.—The only known means of controlling this disease is the use of cultivars that are not prone to fasciation.

DISEASE.—Tip Burn

CAUSE.—Unknown (sometimes excess fertilizer)

SYMPTOMS.—The tips of young unfolding leaves die and turn brown to nearly black. As these leaves continue to expand, they are irregularly shaped and puckered (Fig. 35). Fruit calyces (caps) are sometimes affected (Fig. 36). This can vary from nearly unnoticable browning of the extreme tips of the sepals to browning of entire calyces. Sepals are the narrow, pointed green structures that make up the calyx (fruit cap).

DISEASE DEVELOPMENT.—Tip burn is usually seen only during the fall in Florida, although occasionally it occurs during the winter or spring. It often occurs on the first one or two leaves that emerge after transplanting. Leaf tip burn is most noticable when it occurs on plants that have made considerable growth. The tip-burned leaves in the centers of the plants then contrast sharply with healthy older leaves. Although affected leaves are permanently disfigured, the plants always recover. Usually only one or two leaves per plant are affected.

Tip burn can be caused by a deficiency of boron or calcium. Since other symptoms of boron deficiency, such as yellowing of leaf margins, mottling of leaves, and leaf distortion are not present when tip burn occurs in Florida, boron deficiency probably is not the cause of the disease here. Calcium deficiency would not seem to be the cause, because calcium levels are quite high in most fields in Florida in which strawberries have been grown for a few years. Boron or calcium can become unavailable to plants under certain conditions. It is also possible that under certain conditions the plants may be unable to absorb one of these elements. In either case, if these conditions existed for a sufficiently short time, then tip burn could occur on only one or two leaves, and other deficiency symptoms would not occur or would not be noticed.

Although the cause of tip burn usually is not definitely known, it is sometimes caused by high fertilizer salt concentrations in the soil. This usually occurs after the plants are well established when less water is being applied through irrigation. The soil then begins to dry slightly, and the soil solution (water plus fertilizer salts) becomes more concentrated. If the solution becomes sufficiently concentrated, it causes tissue damage after it is absorbed by the plants. This damage often occurs first as tip burn of unfolding leaves and of sepals if flower buds have emerged from the crown (Fig. 36). If the soil continues drying, burn of leaf margins (typical fertilizer burn) usually occurs one to two weeks after the onset of tip burn. All cases of calyx tip burn that we have seen have been associated with excessively high fertilizer salt levels in the soil.

CONTROL.—No controls are known for tip burn that is caused by factors other than excessive fertility. These plants recover without treatment. Tip burn caused by excessive fertility is controlled by applying sufficient irrigation to lower the concentration of fertilizer salts around the roots of the plants.

DISEASE.—Catface

CAUSE.—Varies (often unknown)

SYMPTOMS.—Catface denotes fruits that are furrowed and gnarled. Dark brown to nearly black areas where the seeds are crowded closely together often occur on the tips (Fig. 37) and sometimes on the sides of catfaced fruits.

DISEASE DEVELOPMENT.—The normal development of a strawberry fruit is dependent upon development of many viable seeds which must be spaced uniformly around the fruit. To produce viable seeds, pollination (transfer of pollen from the stamens to the stigmas) and fertilization (the union of male and female sex cells in the ovule) must take place. Any factors which contribute to incomplete pollination or fertilization may cause catfacing. Some of the known causes of catfacing in Florida are lygus bug injury, anther and pistil blight, albinism, and freeze injury.

Some factors which may contribute to incomplete pollination are lack of viable pollen at certain seasons, insufficient distribution of pollen by wind or insects, and undetermined environmental factors. Catfacing often becomes most severe in Florida after prolonged periods of cold weather, during which time large amounts of water have been applied by sprinkler irrigation for freeze protection. However, it generally does not occur in the fruits that mature from the flowers or buds that are present during the periods of cold weather. It usually occurs in the fruits that begin to mature 6 to 8 weeks after the cold period. Also, catfacing usually is severe only in those fields which produce a very large crop of fruit in response to the prolonged cold weather. Thus, catfacing which occurs after prolonged

periods of cold weather is usually caused by the effect of the low temperatures on the plants as the flowers are being initiated or during the early stages of flower development, rather than by interference with pollination by the irrigation for freeze protection. The nature of the effect of the prolonged periods of low temperature which cause the catfacing in these cases is not known.

When plants are flowering profusely, and periods of several consecutive days of rainy weather occur, or the plants are irrigated for freeze protection for long periods during several consecutive nights, some catfacing may occur. However, severe catfacing seldom can be correlated with either of these conditions.

CONTROL.—Catfacing caused by lygus bugs can be prevented by inspecting for the insects during flowering periods and controlling the insects if they are found. Catfacing caused by anther and pistil blight probably can be controlled by applying fungicides at 3- to 4-day intervals beginning about the time the first flower buds begin to emerge from the crowns in a particular field. There are no known measures for control of catfacing caused by factors other than lygus bugs and anther and pistil blight.

DISEASE.—Proliferation

CAUSE.—Environmental

SYMPTOMS.—Proliferation is the development of leaves and small plants on flowers or fruit (Fig. 38).

DISEASE DEVELOPMENT.—When proliferation occurs in a flower before the fruit has begun to form, usually the entire center (or pistillate) portion of the flower is obscured by the many tiny leaves that develop. When proliferation occurs after the fruit begins to develop, it may vary from one or a few tiny plantlets to almost complete coverage of the fruit.

When the proliferated plantlets are scattered on a fruit, it appears that the seeds have germinated. However, each plantlet is actually attached to the fruit at the same point that the seed is attached. The plantlets are formed by cells within the vascular strand that carries nutrients to each seed.

In some areas, proliferation can be caused by the aster yellows spiroplasm and by the green petal micoplasm-like organism. However, in Florida it appears to be caused by a change from low or moderate temperature to high temperature at a critical time during the initiation or development of the flower bud within the crown. When plants of susceptible cultivars are grown in northern areas, flower buds may be initiated in response to low temperatures or short days during September and early October before the plants are dug. When the plants are dug during the critical period of flower bud initiation and planted into fruit production fields in Florida in early October, proliferation is likely to occur in the first flush of fruit in November and early December. In some cases, proliferation is severe in northern-grown plants that are set within 3 or 4 days after arrival in Florida, but much less severe in plants from the same shipment that are kept under refrigeration for 8 to 10 days before setting. There usually is little or no proliferation in the fall flush of fruits in plants that are dug from northern nurseries after approximately October 10 or in plants that are grown in nurseries in the southern United States. However, proliferation may occur in later flushes of fruit from these plants. In susceptible cultivars, proliferation can occur at any time of year.

CONTROL.—Proliferation in the first flush of fruit in the fall can be controlled by using plants grown in southern nurseries, and by digging plants from northern nurseries after approximately October 10. Presently, the only known control for proliferation throughout the year is the use of cultivars that are not prone to this malady. Some cultivars are prone to proliferation, while others rarely or never show proliferation.

DISEASE.—Yellow Leaf and White Streak

CAUSE.—Unknown

SYMPTOMS.—Entire leaves or leaflets are very light yellow or white, or yellow or white areas occur on individual leaflets (Fig. 39). These areas may occur in the form of streaks, or as areas of various size and shape on individual leaflets.

DISEASE DEVELOPMENT.—This disease is first noticed as new leaves emerge from the crowns after plants are set in the fruit production field. In a specific year, it usually occurs only in plants from a particular nursery, and only a very low percentage of the plants from that nursery are affected. Occasionally most plants in a particular fruit production field are affected to some degree when all plants in the field come from the same nursery.

Usually only two or three of the first five or six leaves produced by an individual plant after it is established in the fruit production field exhibit yellow leaf or white streak or a combination of the two. Generally all subsequently produced leaves are a normal green color. These plants grow normally and appear to "recover" as the normal foliage obscures the affected leaves, or as the affected areas dry and disintegrate. However, some plants produce a few affected leaflets any time a new flush of foliage is produced during the fruiting season. In some cases, the first four or five leaves produced by a very low

percentage of the plants are entirely yellow or white. These plants usually die, apparently because the extreme lack of chlorophyl in the leaves causes them to be unable to synthesize sufficient food.

Although the exact causes of yellow leaf and white streak are not known, they may be caused by the June yellows disease or by genetic mutation in vegetative cells of an occasional stock plant. June yellows is a disorder that occurs commonly in strawberry cultivars or clones that have Blakemore, Howard 17 (Premier), or Auchincruive Climax in their ancestry and is apparently of genetic origin. The disease often does not occur in a cultivar until several years after it has been developed. It then may appear in all stocks of the cultivar over a period of a few years and may result in complete abandonment of the cultivar.

If the disease is caused by mutations in vegetative cells and the affected plants are used for propagation, then all runners produced by these plants may be affected. If these runners are then used for further propagation, the percentage of affected plants will increase with each generation unless they can be rogued out of the nursery.

It is not known whether this disease, as it occurs in Florida, has any effect on per acre yields of fruit. Yields from individual plants that are affected severely enough to be killed or stunted obviously would be greatly reduced. However, the percentage of affected plants in a field is usually so low that there probably would be no effect on overall yield.

CONTROL.—The only known control for this disease is to avoid using plants that have exhibited symptoms for further plant propagation. Frequent inspections of the nursery and destruction of any plants that show symptoms would also aid in control. However, in some cultivars and breeding lines, symptoms apparently do not develop in summer nurseries in Florida.

NEMATODES

Plant parasitic nematodes are microscopic roundworms that live in the soil and attack plants. Several nematodes known to parasitize strawberries are found in Florida's sandy soils (*Belonolaimus, Meloidogyne, Aphelenchoides, Paratrichodorus, Tylenchorhynchus, Xiphinema, Pratylenchus, Longidorus, Criconemoides*). Because of routine soil fumigation, nematodes are seldom a problem in Florida strawberries except when infested plants are set or when nematodes are carried into the nursery on equipment or in drainage water; however, three important nematodes occasionally affect production of nursery plants and reduce fruit yields.

COMMON NAME.—Sting nematode

SCIENTIFIC NAME.—*Belonolaimus longicaudatus* Rau

SYMPTOMS.—Root development is restricted by feeding of the nematode on young roots. In cases of severe infestation, especially in the nursery, many plants form a tight mat of roots 2 to 3 inches (5 to 7.5 cm) in diameter with no roots penetrating deeply into the soil (Fig. 40). Since a restricted root system does not forage in a large volume of soil, the foliar symptoms of nematode infestation of the roots are wilting (due to water deficit in the plants rather than in the soil), nutrient deficiencies of nitrogen, manganese and/or iron (due to inefficiency of debilitated root tips, depletion of nutrients in the severely restricted root zone, and isolation of the roots from any banded fertilizer). Plants remain stunted, become dry and dull, and eventually may die. Heavy infestations at transplanting in nursery or fruiting field result in tight mats of roots composed essentially of the roots which accompanied the transplant. New root initials generally are killed by heavy infestations of the nematode, a symptom reminiscent of fertilizer salt burn.

Light infestations at transplanting or the developing populations encountered late in the season following fumigation have a less drastic effect on root volume. Since root development exceeds or at least keeps pace with the damage caused at fewer feeding sites, symptoms exhibited by both root and plant tops may be less apparent.

DISEASE DEVELOPMENT.—The sting nematode is a migratory, external root parasite. It does not enter roots, but feeds from the outside by means of a stylet through which it sucks the juices from the tissues of the very small roots and root tips. Withdrawing juices or injecting toxins into the tissue causes death of roots or at least inactivation of the growing tips. Affected plants soon have no feeder roots, only brushes of "rat-tail", coarse roots.

COMMON NAME.—Root-Knot

SCIENTIFIC NAME.—*Meloidogyne hapla* Chitwood

This nematode generally appears on nursery plants from more northern states; however, either this or a new strain of the Northern root-knot nematode has adapted to the environmental conditions of central Florida.

SYMPTOMS.—Root-knot nematodes, as the name implies, cause swollen areas (galls) on the roots of infected plants. The galls range from 1/16 to 1/8 inch (1.6 to 3.2 mm) in diameter (Fig. 41); they may occur as spherical swellings or as elongate, convoluted tumors which result from multiple infections. Characteristic of the Northern root-knot nematode are the secondary roots which emanate from the gall

itself. When plants become severely infested, they become unthrifty and may eventually die.

DISEASE DEVELOPMENT.—When juvenile root-knot nematodes enter strawberry plant roots and remain sedentary to maturity, they cause characteristic root galls or knots involving the entire root volume in the area of invasion. This reaction of the plant to nematode invasion differs markedly from the reaction to infection of leguminous roots by nitrifying bacteria wherein nodules or knots formed on roots are easily removed from the surface without destroying the integrity of the root. Subsequent generations of the nematode, produced each 25 to 40 days depending on soil temperature and moisture, may result in elongate, spindle-shaped galls containing several life stages.

The amount of yield loss is dependent not only on the severity of nematode attack, but also on the range of additional stress the plant encounters from other factors such as root-infecting fungi, and inappropriate levels of nutrients, water, and temperature.

COMMON NAME.—Bud or summer crimp nematode

SCIENTIFIC NAME.—*Aphelenchoides besseyi* (Ritzema Bos. Christie

SYMPTOMS.—Leaves are crinkled and dark green, often with reddish coloration in the veins and around the edges of the leaflets. Some leaflets may be narrow and elongate with much distorted mid-ribs.

DISEASE DEVELOPMENT.—This nematode lives as an ectoparasite in the air spaces in the leaf buds. It feeds by puncturing the young tissues with its stylet and extracting the plant juices. The salivary secretions which it injects into the young growing parts cause them to develop abnormally.

CONTROL OF NEMATODES.—All soil in which strawberries are to be planted should be treated with an approved nematicide or soil fumigant. Cultivation of the area should begin 6 to 8 weeks before treatment to ensure that all plant debris is well decayed before the nematicide or fumigant is applied. The soil should be damp, but not excessively wet, for at least two weeks prior to treatment and at the time of treatment. Since strawberries are in the field 6 to 7 months, label instructions must be carefully followed to obtain maximum crop protection during the long growing season.

In the fruit production field, only the row area needs to be treated. In the nursery, the entire area must be treated, and every possible effort should be made to avoid contamination from nontreated soil or drainage water. Although roots in fruiting fields may be protected from gross contamination by the full-bed plastic mulch, nurseries are particularly vulnerable to contamination. Ditching or construction of plastic covered beds along the high side of the nursery may reduce flooding problems.

Only nematode-free plants should be used. This is especially important in the nursery. If plants with even light infestations of nematodes are set in the nursery, the nematodes will reproduce rapidly, and many or all the daughter plants will become infected.

MITES AND INSECTS

Mites and insects are animals that comprise portions of the larger group, arthropods. Numerous arthropods are normally associated with strawberry crops. Some are economically damaging to strawberries and will be discussed individually in this bulletin. Other arthropods, such as Collembola, saprophytic mites, and certain beetles, may serve to decompose dead plant material, aerate the soil, or provide food sources to predators when a pest arthropod food source is not available, but otherwise may have little economic relationship to the crop.

A non-pest group of arthropods normally associated with strawberry crops is the group of beneficial parasites and predators. This group in Florida strawberries includes an important predatory mite (*Phytoseiulus macropilis* (Banks)), an earwig (*Labidura riparia* (Pallas)), wolf spiders (including *Pardosa milvina* (Hentz)), jumping spiders, big-eyed bugs (*Geocoris* spp.), ants, carabid beetles, syrphid flies, and numerous parasitic wasps. These arthropods, living in strawberry fields, survive principally or entirely on other arthropods, including those that would damage the crop. Efforts to conserve this beneficial group through integrated pest management (IPM) pratices, including wise use of pesticides, are important to successful strawberry production.

This section of the bulletin discusses the important arthropod pests that may be found in Florida strawberries produced through currently accepted systems. Components of those systems which have major influence on pest arthropods status are fumigation of beds in the fruiting field and broadcast fumigation in the nursery, use of plastic mulch to cover beds in the fruiting field, use of fruiting plants for one season only, and timing of fruit production for winter and early spring harvests. Changes in strawberry production systems may bring about changes in the pest status of arthropods.

The arthropods discussed are presented in four groups: mites, insects that may produce their damage primarily by feeding on leaves,

insects that feed on fruit and flowers, and insects that feed on strawberry roots or crowns. For each arthropod presented, a description of its appearance, the development of the problem, and control methods will be discussed.

MITES

COMMON NAME.—Twospotted spider mite

SCIENTIFIC NAME.—*Tetranychus urticae* Koch

DESCRIPTION.—The twospotted spider mite (Fig. 42) is about the size of a pencil point. Walking forms have three or four pairs of legs (the number depends on the mite's developmental stage). This mite is usually greenish yellow, although many members of a population may be purplish red during or following cold weather. A prominent dark area is usually present on each lateral side of the abdomen.

DEVELOPMENT OF THE PROBLEM.—Spider mite populations do not usually become sufficiently dense to cause damage in winter and summer nurseries in Florida. Plants grown in nurseries outside Florida are more likely to be infested with spider mites when planted in fruiting beds than are locally grown plants. When infested plants are set in fruiting beds, spider mite damage can appear as early as November. Mites do not fly, but adults produce strands of silk that can be blown by the wind to carry the mites in a process called "ballooning." Mites can infest a strawberry field after plants are set by ballooning from another host such as weeds on ditch banks or farm perimeters.

Mites generally remain below damaging levels in the fruiting field until warm spring weather arrives. At that time, less than five days is required for mites to complete their life cycles. Short life cycles in warm weather and the ability of females to produce many eggs require that the fields be inspected twice weekly during this time.

A hand lens should be used to locate the mites on the undersides of the older leaves. Unthrifty leaves (mottled, chlorotic, russety or partially red) (Fig. 43) or russety berries may indicate that spider mites are present. Dense populations of spider mites on leaves can reduce the ability of the plant to grow and to produce fruit. Under extreme conditions, spider mites can feed on blooms and the developing fruit, reducing fruit size and quality.

The twospotted spider mite is the most frequently encountered arthropod pest of strawberries in Florida. Most growers must take measures to control this pest each year in fruit production fields.

CONTROL.—

1. Set mite-free strawberry plants.
2. Maintain the strawberry field and its environs free of weeds that could be hosts.
3. Conserve naturally occurring predatory mites by eliminating unneeded insecticide or miticide applications.
4. Scout fields and apply recommended miticides only after mites are found.
5. Ensure that miticides used reach the undersides of the lower leaves where mites live.

COMMON NAME.—Cyclamen mite

SCIENTIFIC NAME.—*Stenotarsonemus pallidus* (Banks)

DESCRIPTION.—Eggs, larvae, and adult females are the forms most frequently observed. All forms are so small that they are only faintly visible without optical magnification. Eggs are about half as large as adult females; they are oval and opaque white. Several eggs may be found together. Mobile larvae and non-mobile nymphs are opaque white, while adult females are light brown, about 1/100 inch (0.25 mm) long, and about half as wide.

DEVELOPMENT OF THE PROBLEM.—Damage to strawberries in Florida develops from setting of infested plants. In infested nurseries, mother plants are usually more infested than are daughter plants and should not be set in a fruiting field. The cyclamen mite moves along runners to colonize new plants and feeds on strawberry crowns, flowers, and fruit in addition to leaves. Bees, other insects, birds, field workers, or machinery can move cyclamen mites among fields.

Leaves of colonized plants are small, chlorotic, and wrinkled, with short petioles (Fig. 44). Runners may have tiny thorns (Fig. 45) rather than a smooth texture. Infested plants may also have dry, brown flowers, russety fruits and poorly developed root systems.

Cyclamen mites had not been an economic problem in Florida's strawberries until the 1982–83 season. In a few fields, this mite was the most damaging arthropod pest in the Plant City area during that season.

CONTROL.—

1. Use inspected plants free of cyclamen mites.
2. Use only first-year daughter plants.
3. Inspect fields regularly for outbreaks.
4. Restrict movement of possibly contaminated personnel and machinery out of infested sites and into noninfested sites.
5. Provide the greatest separation in time and distance that is practical between infested fruiting fields and summer nurseries. This may require an agreement from managers of infested farms to destroy their completed crop as early as possible.

6. Since the cyclamen mite has few weed hosts on which to survive the noncropped summer, eliminate cultivated and noncultivated strawberry plants from the area of an infested farm to prevent reinfestation in the following year.

7. Inspect summer nurseries carefully after a season in which the cyclamen mite was present on strawberries in the community.

8. Apply recommended miticides in large volumes of water per acre to ensure penetration into the bud.

INSECTS PRIMARILY AFFECTING FOLIAGE

COMMON NAME.—Fall armyworm

SCIENTIFIC NAME.—*Spodoptera frugiperda* (J. E. Smith)

DESCRIPTION.—The fall armyworm is one of the several noctuid insects that may be present on strawberries. The adult stage is a moth which is usually less than ¾ inch (19 mm) long and frequently brown or gray. Larvae are up to 1½ inches (38 mm) long. They are soft-bodied, brown caterpillars with faint longitudinal stripes. An important distinguishing feature is the presence of a prominent, light colored, inverted "Y" on the head.

DEVELOPMENT OF THE PROBLEM.—Since fall armyworm adults fly at night, they may not be noticed. Adults fly into strawberry fields or develop from pupae already inside the field from previous immigrations. The adult female deposits its eggs in masses containing many eggs covered with "hairs" from the female.

Fall armyworms occur in summer nurseries and in fruit production fields. The larvae feed on strawberry leaves, especially the developing leaves in the center of the plant. Cultivated grassy crops such as sorghum are important hosts of the fall armyworm; thus this species may be more prevalent following or in close proximity to grassy crops.

CONTROL.—

1. Do not plant strawberries following or near crops that have been or currently are infested heavily with the fall armyworm.

2. Scout the strawberries weekly, particularly during September through early December.

3. Apply recommended pesticides as required to ensure coverage in the area of developing leaves.

COMMON NAME.—Southern armyworm

SCIENTIFIC NAME.—*Spodoptera eridania* (Cramer)

DESCRIPTION.—The southern armyworm is one of the noctuids described in general under "fall armyworm." Larval southern armyworms are marked with purple triangles on their backs (Fig. 46); each lateral side has a faint yellow, longitudinal stripe broken above the middle pair of true legs (near the head) by a dark, almost round spot.

DEVELOPMENT OF THE PROBLEM.—Southern armyworm infestations occur in the manner of the general noctuids. Eggs are laid in masses in summer nurseries and fruiting fields but are without the dense covering of hair typical of the fall armyworm. As do the fall armyworms, these larvae feed on leaves and prefer those developing in the bud. Although the southern armyworm is a pest of many crops in the strawberry growing regions of Florida, it rarely reaches economic levels in strawberries.

CONTROL.—

1. Scout strawberries weekly, particularly during September through early December.

2. Apply recommended pesticides as required to ensure coverage in the area of developing leaves. Pesticides applied to control the more prevalent fall armyworm should also control the southern armyworm.

COMMON NAME.—Cabbage looper

SCIENTIFIC NAME.—*Trichoplusia ni* (Hubner)

DESCRIPTION.—The larval cabbage looper is a green caterpillar with white longitudinal stripes. This caterpillar is easily distinguished from other caterpillars found on strawberries by the presence of only three pairs of false legs on the rear half of the abdomen rather than four or more pairs. This noctuid is usually smaller in cross section than are caterpillars of similar length that may be found on strawberries.

DEVELOPMENT OF THE PROBLEM.—Adult cabbage looper moths lay eggs singly on strawberry plants. Larvae developing on the strawberries may be found on outer leaves as frequently as on the central leaves. Cabbage loopers are not routinely found in strawberries grown in Florida, although they may occur from time to time.

CONTROL.—Cabbage loopers are usually controlled by insecticides applied to control several other insects. Special applications for cabbage looper control are rarely required.

COMMON NAME.—Granulate cutworm

SCIENTIFIC NAME.—*Feltia subterranea* (Fabricius)

DESCRIPTION.—Granulate cutworms are much like the other foliage feeding noctuids discussed. These caterpillars are brown with

faint chevron markings (Fig. 47). Granulate cutworms curl into a C-shape when at rest or when disturbed.

DEVELOPMENT OF THE PROBLEM.—Adult cutworms are small moths. The female lays eggs singly on strawberry leaves. When larvae are found, they are usually at rest on the plastic mulch under the strawberry leaves.

This species is usually found each season in winter and summer nurseries and in fruit production fields; however, granulate cutworms rarely cause economic damage. They occasionally cause significant damage in nurseries by eating from the central buds of plants, causing the plants to produce few runners. When these plants are transplanted, numerous side crowns develop and form plants with large masses of leaves that are smaller than normal. In fruit production fields, these plants produce small, late fruit and an overall low yield

CONTROL.—Usually insecticides applied to control other insects will also kill granulate cutworms. For that reason, and since densities are rarely high and each larva causes little damage, treatments applied specifically for the granulate cutworm are rarely necessary.

COMMON NAME.—Tiger moth larvae, including woolly-bear and saltmarsh caterpillars

SCIENTIFIC NAME.—Arctiidae

DESCRIPTION.—Tiger moth larvae are heavily clothed in long "hairs" (Fig. 48) and may appear larger than the noctuid caterpillars found in strawberries. They can be found in nurseries and fruit production fields.

DEVELOPMENT OF THE PROBLEM.—Tiger moth caterpillars are frequently abundant in weeds growing near strawberry fields. Consequently, these larvae may be most numerous on border rows and near ditch banks. Adult tiger moths lay their eggs in masses of up to 100 eggs. When an egg mass has been laid on a strawberry plant, that and adjacent plants may be fully defoliated.

CONTROL.—Applied controls are rarely required for this infrequent pest.

1. Control weeds along ditch banks and field margins.
2. Scout field portions near ditch banks and perimeters, then spot-treat infested areas with recommended insecticides.

COMMON NAME.—Strawberry root aphid

SCIENTIFIC NAME.—*Aphis forbesi* Weed

DESCRIPTION.—Aphids in general are usually about 1/16 inch (1.6 mm) long and slightly less in width. They have two pipe-like projections extending from their posterior ends. Most are wingless, but winged forms occur. The strawberry root aphid is bluish green.

DEVELOPMENT OF THE PROBLEM.—In the late fall, winged adult aphids fly into strawberry fruiting fields where they come to rest on strawberry leaves. Winged adults produce female young that usually produce young without mating. The aphid life cycle is completed within a few days in warm weather; thus numbers of aphids can increase quickly. Under the cultural conditions of strawberries in Florida, the strawberry root aphid develops on leaves. It ingests plant juices, and can devitalize the plant when present in large numbers. This aphid is found in low numbers every year on strawberries grown without pesticides in the Plant City area; it is rarely an important pest.

CONTROL.—Scout fields weekly and apply recommended insecticides when populations warrant. Insecticides applied to control other insects usually control the strawberry root aphid.

INSECTS PRIMARILY AFFECTING FRUITS AND FLOWERS

COMMON NAME.—Field cricket

SCIENTIFIC NAME.—*Gryllus firmus* (Walker) and *G. rubens* (Scudder)

DESCRIPTION.—Field crickets are the frequently encountered, dark brown insects with long legs and long antennae, much like the crickets sold for fish bait (Fig. 49). Males of this species may be noted in warm weather by their songs, a series of short chirps, from under the plastic mulch. Adult field crickets are winged. The young are wingless but otherwise similar to adults.

DEVELOPMENT OF THE PROBLEM.—Soon after strawberry beds are covered with plastic mulch, field crickets crawl through planting holes in the plastic and hide in the protected environment on top of the soil bed. Adult females lay eggs there, and nymphs develop in the early spring. Adults and nymphs feed similarly. They occasionally may chew around strawberry crowns, but they inflict their most serious damage upon the fruit (Fig. 50). Field crickets scrape seeds and some outer fruit tissue from hard fruit, rendering the strawberries unsaleable.

This insect group has caused economic damage on some farms in the Plant City area in recent years. The damage has been attributed mistakenly to seed-cracking birds. The most serious damage occurs two to five months after beds are covered with mulch.

CONTROL.—

1. Apply residual insecticides to the plant bed before plastic mulch is installed.

2. Scout fields when strawberries are present. Piles of cracked seeds and small fecal pellets under damaged, hard strawberries indicate the presence of this insect.

3. Apply recommended insecticides to plants upon which crickets may later feed. Approved cricket baits in row middles should reduce cricket numbers considerably.

4. Apply insecticides to ditch banks and field margins that may harbor crickets.

COMMON NAME.—Flower thrips

SCIENTIFIC NAME.—*Frankliniella cephalica* (Crawford)

DESCRIPTION.—Flower thrips in strawberries are usually yellow. They are 1/20 inch (1.3 mm) long and much more narrow than long. Adult thrips have wings while nymphal thrips do not.

DEVELOPMENT OF THE PROBLEM.—Thrips invade strawberry fields from blooming citrus, clover, and wild flowers. Although thrips are not strong fliers, winds aid their movement into flowering strawberry fields. Thrips rasp the portions of the strawberry flower that develop into fruit, causing it to develop poorly. Damaged green fruits may become bronze or grayish (Fig. 51), and very fine shallow cracks may develop in their surfaces. As these fruits ripen, they remain dull in appearance. Thrips damage can easily be mistaken for damage caused by powdery mildew or by spray burn. This insect occurs on every farm in every year and may require control measures.

CONTROL.—

1. Scout fields at least once a week when strawberries are in bloom. This is particularly important in the late winter and early spring when thrips activity is at its peak. Thrips may be detected by thumping opened flowers onto the observer's hand or by blowing lightly into the flowers. A magnifying lens may be required to see the insect.

2. Apply recommended pesticides when populations warrant.

COMMON NAME.—Plant bugs, including the tarnished plant bug.

SCIENTIFIC NAME.—*Taylorilyqus pallidulus* (Blanchard) and *Lyqus lineolaris* (Palisot de Beauvois)

DESCRIPTION.—Plant bugs are usually brown, grayish brown, or green (Fig. 52). They are about 1/4 inch (6.4 mm) long and about half as wide. Since they are true bugs, they have sucking mouth parts, and their forewings are hard at the basal half and membranous at the distal half. Immature plant bugs (nymphs) look like adults but do not have wings.

DEVELOPMENT OF THE PROBLEM.—Plant bug adults can enter a strawberry field and cause economic damage at any time that strawberry flowers or very small fruit are present. Adults may reproduce within the field, resulting in the presence of nymphs. Both nymphs and adults feed by inserting their sucking mouthparts into flowers or small fruit, causing the fruit to develop with a catface.

CONTROL.—

1. Scout fields weekly during the blooming period.

2. Apply recommended insecticides when populations warrant.

COMMON NAME.—Sap beetle

SCIENTIFIC NAME.—Nitidulidae

DESCRIPTION.—Sap beetle adults found on strawberries are usually 1/8 inch (3.2 mm) to 1/4 inch (6.4 mm) long and brown or tan. Their larvae are about the same size as the adults, but are soft and white and may have lateral projections on abdominal segments. These are the same beetles found in citrus fruits that have fallen from trees and rotted.

DEVELOPMENT OF THE PROBLEM.—Sap beetle adults are attracted to damaged or overripe strawberries fermenting in the field. Adults feed on and lay their eggs in the deteriorated fruit. The eggs hatch, and larvae develop also to feed there and in nearby overripe or damaged fruit. Sap beetles do not normally damage a sound strawberry. Sap beetles can be present at any time that overripe fruits are present; however, the beetles become most numerous in warm weather and when large numbers of fruits have been abandoned in fields.

Sap beetles are not usually economically important in fresh market strawberries. However, when overripe fruits are harvested for processing, sap beetles may infest the fruit and render the crop unmarketable.

CONTROL.—

1. Maintain sound fruit through good disease and insect control practices and through preventing damage from birds.

2. Pick fruits before they become overripe.

3. Remove all damaged or overripe fruit from the field, particularly in warm weather.

4. Do not cease picking from portions of a field while continuing to harvest from other portions.

5. Scout fields for the presence of sap beetles or for conditions favorable for sap beetles development.

6. Be informed when neighboring strawberry fields are abandoned.

7. Apply recommended insecticides when conditions warrant.

COMMON NAME.—Tomato fruitworm or corn earworm

SCIENTIFIC NAME.—*Heliothis zea* (Boddie)

DESCRIPTION.—The tomato fruitworm is a noctuid similar to the generalized noctuid described under the section "Fall armyworm." The color of the larval form varies greatly, but yellow or pale green often dominates; sometimes tomato fruitworms that have fed on ripe strawberries have pink among their colors. Small spines with flat, circular bases over most of the body distinguish these larvae from other noctuids in strawberries.

DEVELOPMENT OF THE PROBLEM.—Adult tomato fruitworm moths can fly into strawberry fields in almost any month. Female moths lay eggs singly on leaves, where the eggs develop into caterpillers that feed on leaves and fruit.

CONTROL.—

1. Scout fields weekly, especially during the fruiting season.
2. Apply recommended insecticides as populations warrant.

COMMON NAME.—Pamera

SCIENTIFIC NAME.—*Pachybrachius vinctus* (Say) and *P. bilobatus* (Say)

DESCRIPTION.—Pamera adults and nymphs are tan or brown bugs (Fig. 53) about ⅛ to ¼ inch (3.2 to 6.4 mm) long with narrow bodies and long antennae. The upper portions of the first pairs of legs are enlarged. The basal half of the forward pair of wings is hard, and the distal half is membranous. The bugs feed with piercing and sucking mouth parts.

DEVELOPMENT OF THE PROBLEM.—Pameras are very common on many of the weeds found associated with strawberry fields and their environs and are therefore most numerous in rows bordering the weeds. These insects are particularly noticeable beginning in the late winter when young fruit is present. In fields not treated with insecticides, pameras accumulate in large numbers on the plastic mulch around individual plants. Although pameras are capable of flight, they rarely fly, but quickly crawl under a plant when disturbed.

The insect's mouthparts are inserted into leaf petioles and fruit, sometimes causing the young fruit to fail to develop fully. Little is known about the numbers of pameras that are required to cause economic losses, but significant losses appear unlikely when only a few bugs per plant are present.

CONTROL.—

1. Practice weed control in row middles and along field margins.
2. If insecticides applied to control other arthropods do not maintain populations below moderate levels, apply approved insecticides specifically to control pameras.

INSECTS PRIMARILY AFFECTING ROOTS AND CROWNS

COMMON NAME.—Lesser cornstalk borer (mistakenly called bud worm)

SCIENTIFIC NAME.—*Elasmopalpus lignosellus* (Zeller)

DESCRIPTION.—The damaging larval stage of this insect is about ½ inch (12.7 mm) long. It is bluish green with purple or brown bands encircling the body (Fig. 54). The adult is a tiny moth.

DEVELOPMENT OF THE PROBLEM.—The lesser cornstalk borer can cause extensive damage in summer nurseries and in fruit production fields. Adult borers deposit single green or white eggs on strawberry leaves. Larvae developing from these eggs bore into the crown of the strawberry plant at the soil line. A silk tube (Fig. 55) is often formed between this hole and the soil. During an active infestation, frass may be pushed to the outside of the plant. Larvae usually leave the plant within three weeks and pupate at the soil line inside a silk cocoon.

Lesser cornstalk borers attack mother and daughter plants in the summer nursery. Mother plants and large, rooted daughter plants are girdled just below the bud, resulting in wilting (Fig. 56) and death of affected plants. A longitudinal cut through the crown of such a plant reveals a small tunnel extending around the crown just below the bud (Fig. 57). Young, unrooted daughter plants are also attacked. The borer generally enters these plants from underneath and hollows out the crown area, resulting in wilting and death.

In fruit production fields, usually the first signs of damage by the lesser cornstalk borer are very small, round holes in the youngest leaves. (Small armyworms may cause similar damage.) These holes are made by the very small larvae tunneling through the bud. As the larva enlarges, it moves into the crown and girdles the plant below the bud, resulting in wilting and death of the plant. Wilting caused by the lesser cornstalk borer may be mistaken for anthracnose disease.

The attack by the lesser cornstalk borer in corn, sorghum, peanut, and some other crops is usually more severe in areas of fields that are dry and sandy. However, it is not known just what conditions favor this pest in strawberries. Strawberries grown in fields previously planted in corn, sorghum, peanut, pea, cowpea, or bean may be attacked by the lesser cornstalk borers that survived in crop residues.

CONTROL.—

1. Do not plant strawberries in or near fields recently planted in hosts of the lesser cornstalk borer—corn, sorghum, peanut, pea, cowpea, or bean. This is especially important if those crops were known to have had an infestation of the lesser cornstalk borer.

2. Scout for damaged plants (wilted or brown leaves in the center; holes, frass, or tunnels at the base).

3. Apply recommended pesticides when signs of an infestation are found.

COMMON NAME.—Mole cricket

SCIENTIFIC NAME.—*Scapteriscus acletus* Rehn and Hebard and *S. vicinus* Scudder

DESCRIPTION.—These unusual crickets are tan and are as large as 1½ inches (38.1 mm) long. They have front legs that are short and broad for digging (Fig. 58). Their raised tunnels, found in moist soil, are more easily seen than are the insects. On warm nights, male mole crickets can be detected by their songs, which are much like those of field crickets except that the song of the mole cricket continues for long periods without a pause.

DEVELOPMENT OF THE PROBLEM.—Female mole crickets lay eggs in the soil during the warm days of spring. The eggs produce small, wingless nymphs that are otherwise similar in appearance and behavior to the adult. Before early July, most nymphs develop to adults that later enter the soil bed of the fruiting field through planting holes in the plastic mulch. There they feed on roots and crowns of strawberry plants. Since strawberries are planted with a developing root system, the plants quickly extend their roots and usually withstand the below-ground damage from this insect. Crowns are more vulnerable and are susceptible to damage by the mole cricket.

CONTROL.—

1. Do not locate strawberries near bahia pastures or other crops that are suitable hosts for the mole cricket.

2. Apply a residual insecticide to the soil bed before installing the plastic mulch.

3. Scout for mole crickets and their tunnels.

4. Apply recommended insecticides to plants when conditions warrant. Since many mole crickets remain under the plastic mulch, this measure has limitations.

5. Apply recommended insecticidal baits to row middles.

6. Apply recommended insecticides to ditch banks and field margins to reduce further invasion of mole crickets.

COMMON NAME.—Wireworm or click beetle

SCIENTIFIC NAME.—Elateridae

DESCRIPTION.—Adults are beetles, usually about ½ inch (12.7 mm) long, with sides that are conspicuously parallel and distinctly rounded at both ends. They are brown, gray, or black. When placed on their backs, adults will flip themselves over with an accompanying "click"; thus the name "click beetle." Larval wireworms are white, light brown or yellow, as much as ¾ inch (19 mm) long, distinctly round in cross section, and generally look like small sections of wires (Fig. 59).

DEVELOPMENT OF THE PROBLEM.—Wireworm adults may feed on above-ground strawberry plant parts, but their damage is rarely important in strawberries. A single generation of their larvae may occur in the soil of strawberry beds during one crop cycle. Since beds are normally fumigated and covered with plastic mulch in Florida's commercial strawberry production, larvae usually do not develop in sufficient numbers or size to threaten strawberry plants. Larvae may feed on strawberry roots and crowns occasionally.

CONTROL.—Apply residual insecticides to the soil before installing plastic mulch.

MISCELLANEOUS INSECTS

Other arthropod species may damage strawberry plants or fruit on occasions. Although details of these arthropods will not be discussed, it is wise to be aware of their status as potential pests. Among this group are flea beetles, leaf hoppers, leaf rollers, leaf tiers (Fig. 60), grasshoppers, stink bugs, ants, May beetle larvae, rice beetles, and fruit flies.

One other potential insect pest has the unusual status of being normally a beneficial predator. A species of carabid beetle, *Harpalus* sp., sometimes may eat seeds from strawberries, as does the field cricket, although this beetle more frequently feeds on other insects.

Snails and slugs, known as gastropods rather than arthropods, sometimes may damage strawberries. Damage from this group is unusual in Florida's commercial strawberry production. However, pesticides are available for control of snails and slugs if needed.

TIME OF APPLICATION OF PESTICIDES

Since it is important to prevent build-up of diseases rather than to try to control them after they occur, fungicides should be applied on a regular schedule throughout the season. Insecticides and miticides

may be omitted until signs of a particular pest are noticed. However, fields should be inspected closely and frequently in order to detect insects or mites in the early stages of infestations, and appropriate pesticides should be applied as soon as conditions warrant. Mites are much easier to control while populations are sparse rather than dense.

PRECAUTIONS TO BE FOLLOWED WITH PESTICIDES

Keep all pesticides in a locked building or cabinet at all times; read the entire label on any pesticide before using the product. Handle all pesticides with care and heed directions and precautions on the label. Wear protective masks, gloves, and clothing as recommended for the specific pesticide whenever any pesticide is being handled or applied. Never eat, chew tobacco, or smoke while handling or applying pesticides; always wash hands and arms with soap immediately after handling any pesticide. Take precautions to ensure that no one enters a treated area before the safe reentry time has elapsed.

In case of accidental contact with any of these products, remove contaminated clothing and wash the pesticide off the body as quickly and thoroughly as possible.

Do not wear contaminated clothing again until it has been washed thoroughly. In cases off suspected pesticide poisoning, see a doctor immediately, tell him what pesticide is suspected and show him the label from the pesticide container if possible.

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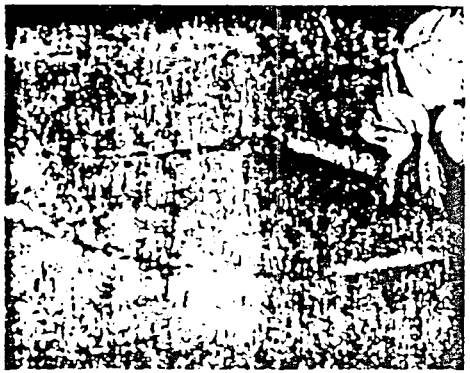

Figure 1.—Anthracnose on stolons.

Figure 2.—Anthracnose on petiole.

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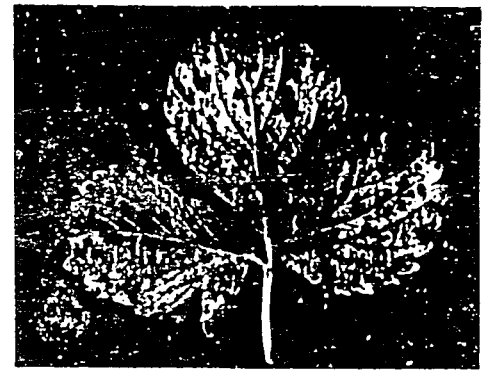
Figure 4.—Bud rot caused by *S. rolfsii* (arrow-sclerotia).

Figure 5.—Verticillium wilt.

Figure 6.—Common leaf spot.

Figure 7.—Leaf blight.



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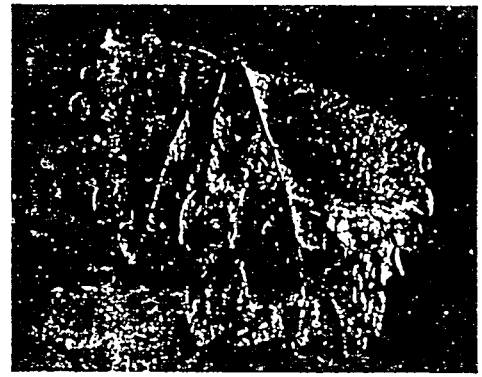

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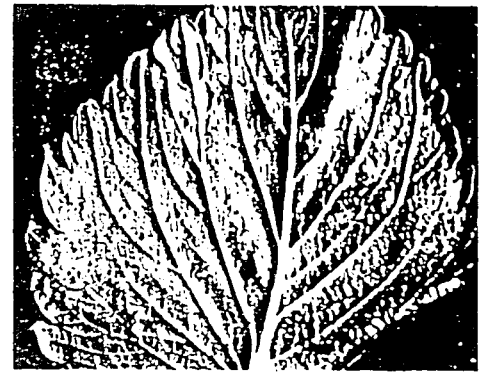

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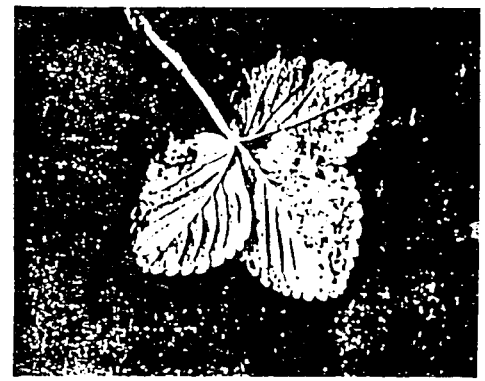

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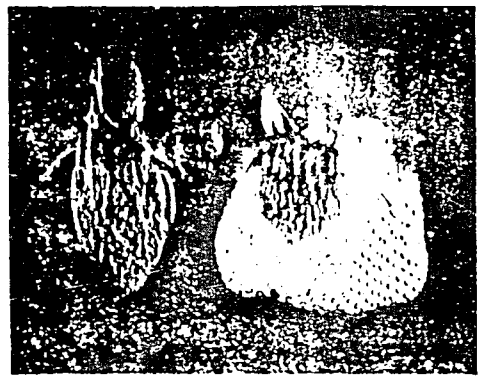

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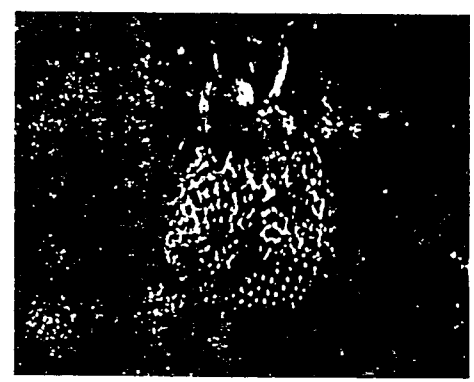

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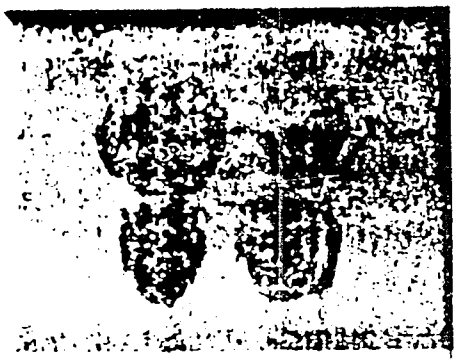

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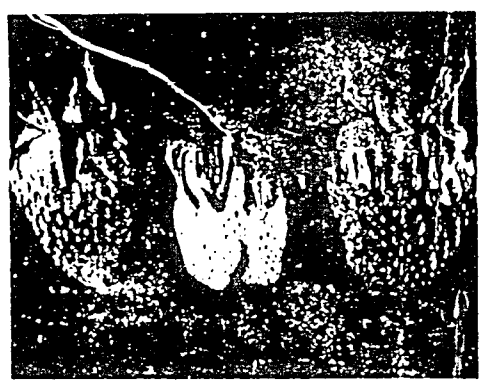

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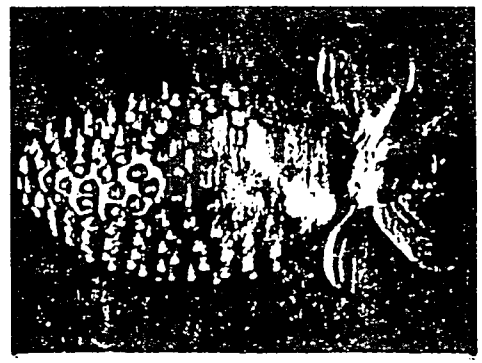

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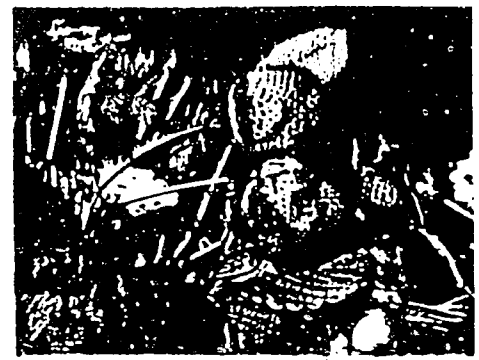

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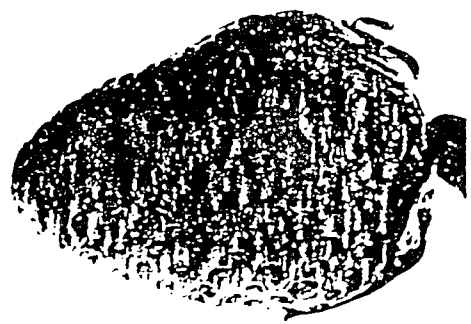

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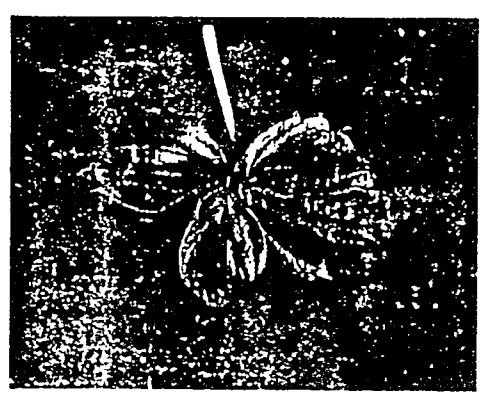

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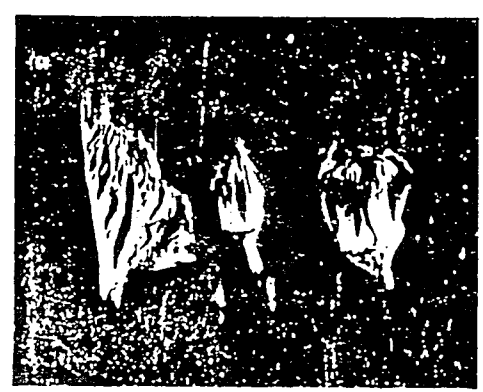

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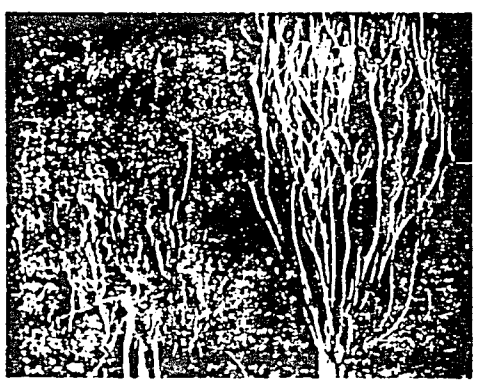

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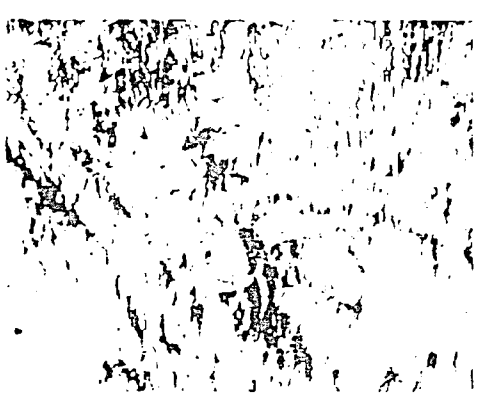

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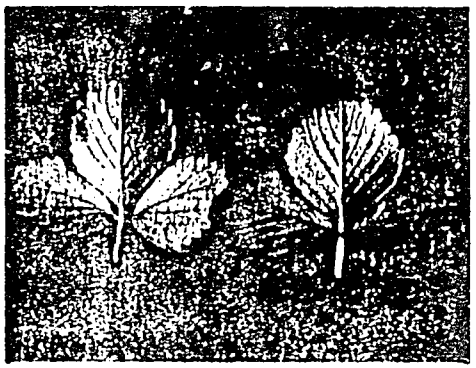

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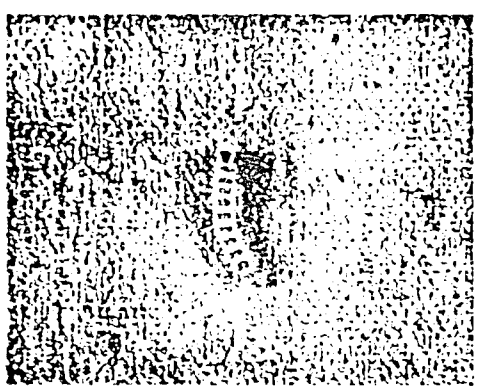

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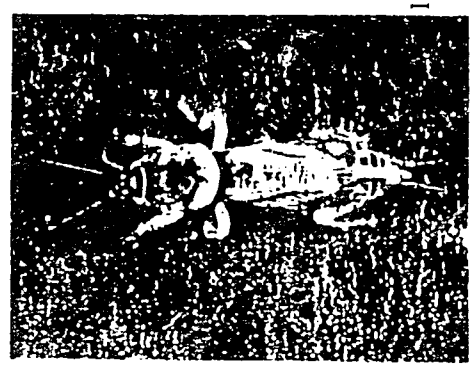

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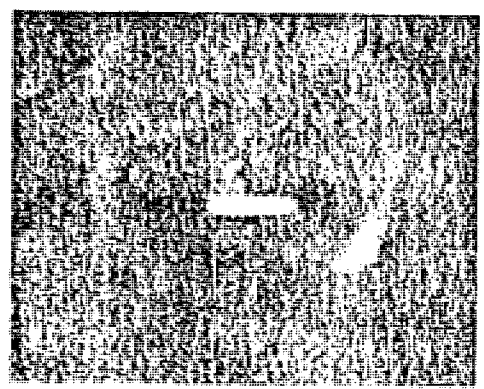

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PROTECT

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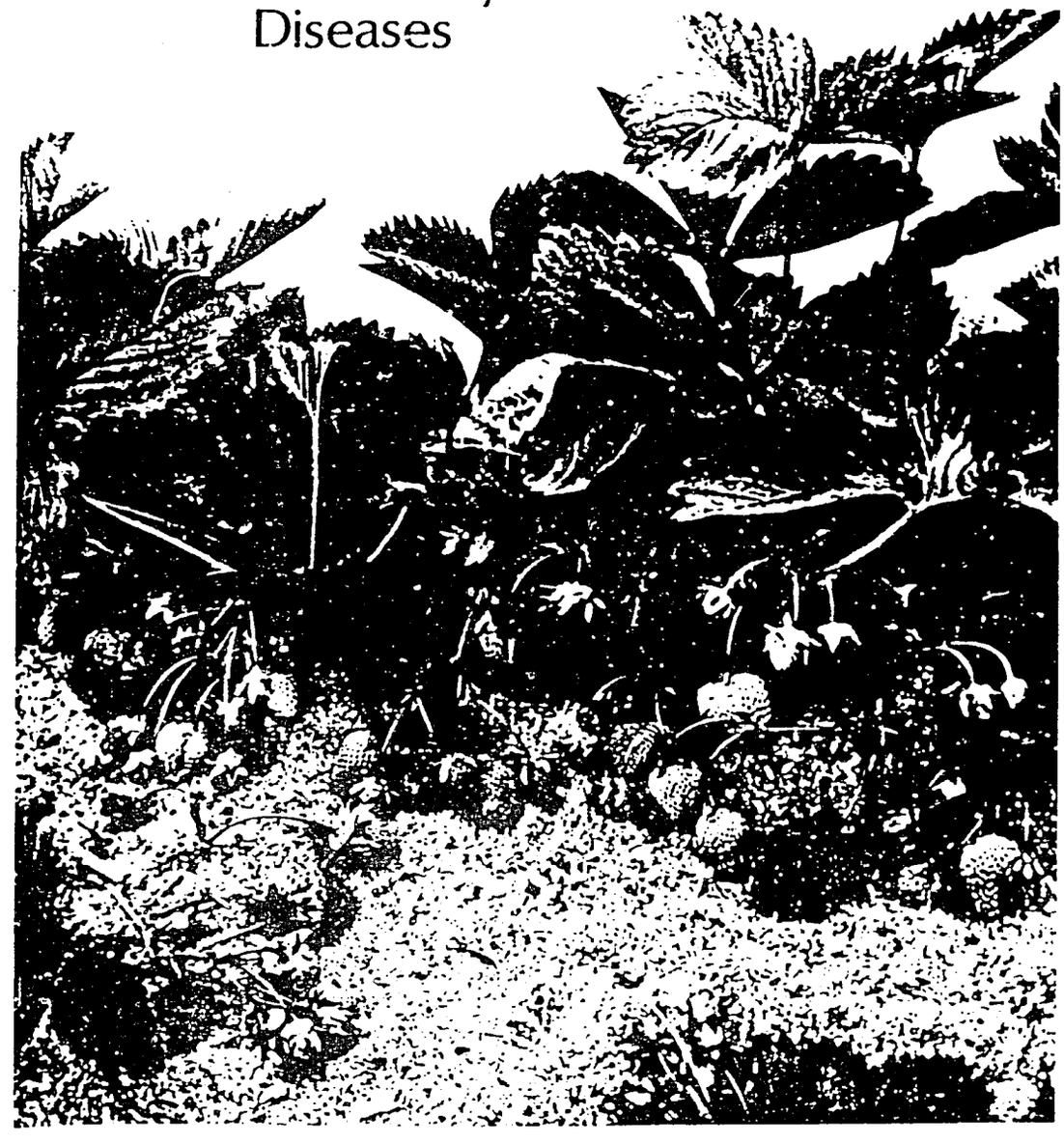
Strawberry Diseases



UNITED STATES
DEPARTMENT OF
AGRICULTURE

FARMERS'
BULLETIN
NUMBER 2140

PREPARED BY
AGRICULTURAL
RESEARCH
SERVICE

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STRAWBERRY DISEASES

Strawberries are attacked by many diseases that vary widely in their destructiveness and distribution. The ideal way to cope with these diseases is to hold them in check through preventive measures.

In most localities losses may be reduced by (1) using adapted cultural practices, (2) selecting adapted varieties, and (3) planting disease-free stock.

Cultural practices.—Use the cultural practices that are adapted to your locality. These will enable you to grow vigorous plants. Two cultural practices recommended in most localities are crop rotation and frequent renewal of plantings and plant stocks.

Varieties.—Select varieties that do well in your locality. If a particular disease is a problem, choose, if possible, varieties resistant to it.

Disease-free stock.—Use disease-free stock for planting new fields. Only a few of the major diseases are now common throughout the country. But most of them can be introduced into new areas by planting infected stock.

When you buy planting stock, it is best to patronize nurseries that sell plants certified to be disease-free by the State plant-inspection service.

If you use runner plants from old fields to set new fields, do not use any from plants that you know or suspect are diseased.

DISEASES OF THE ENTIRE PLANT

Diseases of the entire plant include all the virus diseases of strawberries and leaf variegation (also called spring yellows).

Virus Diseases

Viruses are disease-causing agents so small they cannot be seen, even through a microscope. Several viruses infect strawberries. Most strawberry virus diseases are a combination of two or more of these viruses (a virus complex).

Though one virus or even certain combinations of viruses may not cause the plant to show obvious symptoms or noticeable loss of vigor, their presence in the plant does weaken it. Loss of vigor may show up in the weakened plant if growing conditions are unfavorable. Obvious symptoms may appear if the plant is infected with an additional virus.

A strawberry plant can never be rid

of a virus infection (except under some specialized experimental techniques), and the infection passes on through runners to all daughter plants. Most of the viruses are spread from plant to plant by aphids.

Virus diseases that can be recognized by clear-cut symptoms in varieties include crinkle, yellows, multiplier, leaf roll, and aster yellows; these are described under "Symptoms."

Other virus diseases that ordinarily produce no identifying symptoms in varieties are not listed. The viruses causing these diseases can be identified only through a process called indexing. Indexing consists of grafting the plant to be tested to an indicator plant. If the plant being tested is virus infected, the indicator plant shows clear-cut symptoms.

Distribution.—Virus diseases that do not produce obvious symptoms are widespread in the Eastern United States and occur in every strawberry-producing section of the country.

PN-5844

Crinkle symptoms in a Marshall strawberry plant.

PN-5845

Yellows symptoms in a Marshall strawberry plant.

Virus diseases that can be seen in varieties include crinkle and yellows which are prevalent in the Pacific States, multiplier which is found principally in the North Central States, leaf roll in the Northeastern States, and aster yellows throughout the United States.

Symptoms.—Symptoms of the recognizable virus diseases are listed below.

Crinkle.—Plants are a lighter shade of green than normal. Leaves tend to lie flat on the ground. Leafstalks are short. Some leaves are distorted or wrinkled; usually these leaves have many pinpoint-size, yellow spots scattered over the surface.

Yellows.—Plants are dwarfed and have very few runners. Leaves usually cup upward; they have dull green centers and yellow edges.

Multiplier.—Plants are spindly and have many crowns, sometimes as many as a hundred. Leafstalks are thin and somewhat shorter than normal. Leaves are from one-third to one-half normal size. There are only a few very short runners or none.

Leaf roll.—Leaves tend to cup downward and often are rolled or twisted into a tube.

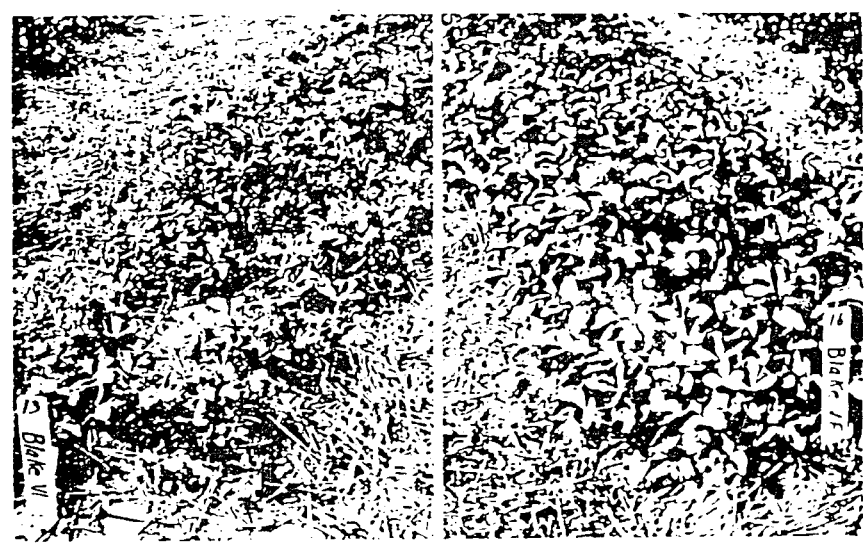
Aster yellows.—Early symptoms are yellowing, dwarfing, and cupping of young leaves. Later, most plants showing early symptoms die suddenly, as do all attached runner plants. Sometimes abnormal green, leafy flowers are produced before the plant dies. When the disease appears in a field, usually only a few scattered plants are affected. Sometimes, however, over half the plants in a field may be affected; the rate of spread varies greatly from year to year.

Damage.—All virus diseases weaken plants, reduce runner formation, and hold down berry yields.

Crinkle and yellows do the most damage. Crinkle often reduces yields by 50 percent or more. Yellows reduces both quantity and quality of yield and shortens the life of the planting. Losses from both diseases are greatest in strawberries of the Marshall variety, which is very sensitive to both diseases. Shasta, Tioga, and Northwest varieties are rather tolerant to both diseases.

Virus diseases that do not produce obvious symptoms may reduce yields as much as 50 percent, judging by tests conducted on experimental planting stock. Strawberries of all varieties appear to be weakened by these diseases, but some are more sensitive than others.

What to do if disease occurs.—If only a few plants in a field show



PN-5846, PN-5847

Virus-infected and virus-free Blakemore plants grown under the same experimental conditions. Infected plants at left have no obvious symptoms other than poor vigor. Poor vigor may also result from a number of unfavorable growing conditions.

symptoms of crinkle or yellows, remove them at once, and apply insecticides to control aphids. This is especially helpful in fields less than 1 year old. If these diseases appear in many plants, ask your county agent for help in determining where the infection is coming from and whether removing infected plants will be practical.

If multiplier or leaf roll appears in the field, it may help to take out diseased plants when you cultivate.

Plants with aster yellows may be left in place; usually they die, and healthy plants grow over them.

Prevention.—To prevent damage from virus diseases, plant only virus-free stock[1] and grow it under conditions that will prevent or reduce the movement of insect virus carriers into the planting. Locate new plantings as far as possible from existing strawberry fields; plow under old fields immediately after harvest; and apply insecticides to control the winged aphids that are present in the early spring and the fall. Virus-free stock has proved to be more vigorous and productive than common (or virus-infected) stock, even in localities that have no apparent virus-disease problem.

Virus-free plants are available from nurseries the country over. Plants grown under a State-supervised certification program and labeled "essentially virus free" or "substantially virus free" are preferable to those labeled merely "grown from virus-free plants." To obtain certification of their stock, nurserymen are required to use special planting stock and to follow specified isolation or control practices, or both. Virus-free plants of most varieties are available.

Virus-free strawberries can become infected after they are planted if virus-infected plants are near and strawberry aphids are present.

In areas where virus diseases have been a problem, insecticides should be carefully applied in the early spring and fall to prevent a buildup of winged aphids on new beds.

Apply the insecticide after the young plants are well established and repeat the application in 3 weeks if any aphids are present. In the early spring, make another application before the plants begin to bloom. If aphids persist after fruit is set, apply insecticides, being careful to observe the minimum days between application and harvest. If necessary, insecticides can be applied after harvest or about the first of September. Information on insecticides may be obtained from your State agricultural extension agent.

Ingredients for sprays are available in a concentrated form, either as an emulsifiable concentrate or a wettable powder, that should be diluted with water. For a low-gallon spray (10 gallons or less per acre), use only an emulsifiable concentrate; a wettable powder may clog the nozzles of the sprayer.

[1] In this publication "virus-free stock" refers to plants that are substantially free from recognized viruses. There is no way to determine whether a plant is free from all viruses.

Leaf Variegation (Spring Yellows)

Leaf variegation is a noninfectious disease caused by a defect in the hereditary makeup of the plant. It has been found in at least 40 varieties of strawberries. Among these are Blakemore, Dixieland, Howard 17 (Premier), Vermilion, and most everbearing varieties.

Distribution.—Leaf variegation can be found in any section of the United States. It is not common in most modern varieties.

Symptoms and damage.—The green of new leaves becomes pale and faintly spotted or streaked with

USE OF PESTICIDES

This publication is intended for nationwide distribution. Pesticides are registered by the Environmental Protection Agency (EPA) for countrywide use unless otherwise indicated on the label.

The use of pesticides is governed by the provisions of the Federal Insecticide, Fungicide, and Rodenticide Act, as amended. This act is administered by EPA. According to the provisions of the act, "It shall be unlawful for any person to use any registered pesticide in a manner inconsistent with its labeling." (Section 12 (a) (2) (G))

EPA has interpreted this section of the act to require that the intended use of the pesticide must be on the label of the pesticide being used or covered by a Pesticide Enforcement Policy Statement (PEPS) issued by EPA.

The optimum use of pesticides, both as to rate and frequency, may vary in different sections of the country. Users of this publication may also wish to consult their Cooperative Extension Service, State agricultural experiment stations, or county extension agents for information applicable to their localities.

The pesticides mentioned in this publication are available in several different formulations that contain varying amounts of active ingredient. Because of this difference, the rates given in this publication refer to the amount of active ingredient, unless otherwise indicated. Users are reminded to convert the rate in the publication to the strength of the pesticide actually being used. For example, 1 pound of active ingredient equals 2 pounds of a 50-percent formulation.

The user is cautioned to read and follow all directions and precautions given on the label of the pesticide formulation being used.

Federal and State regulations require registration numbers. Use only pesticides that carry one of these registration numbers.

USDA publications that contain suggestions for the use of pesticides are normally revised at 2-year intervals. If your copy is more than 2 years old, contact your Cooperative Extension Service to determine the latest pesticide recommendations.

The pesticides mentioned in this publication were federally registered for the use indicated as of the issue of this publication. The user is cautioned to determine the directions on the label or labeling prior to use of the pesticide.

yellow. The intensity of the spotting or streaking differs with variety and season. Symptoms may appear in the spring, disappear during warm weather, and reappear in the fall or the next spring. Sometimes the symptoms become progressively worse each spring until plants are stunted and weak and leaves are almost white.

Badly affected plants are unproductive and die prematurely. Affected plants never recover; all their runner plants show variegation in some degree.

Prevention.—There is no known cure for leaf variegation. It can be prevented, however, by use of nonvariegated planting stocks. Certain strains or stocks of Blakemore and Howard 17 that are comparatively free of this disease are available.

ROOT DISEASES

Red stele, verticillium wilt, black root-rot, and nematode infection are the major root diseases. Red stele and verticillium wilt are caused by fungi. The cause of black root-rot is not known. The most common damage by nematodes is caused by two types that enter the roots to feed.

Red Stele

Red stele, the most serious fungus disease of strawberries in the United States, attacks plants during the late winter and spring. The fungus that causes the disease attacks no other crop except loganberries. The fungus does not persist in soils in the South and persists infrequently in well-drained soils of any area. It persists, however, in all other soils.

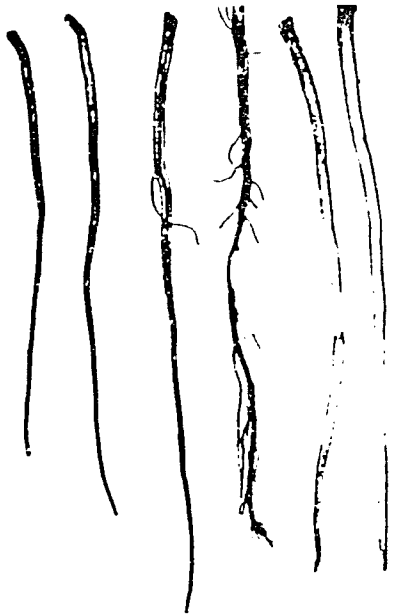
Red stele is spread from one area to another principally by distribution of diseased plants. It is spread within an area by water that moves within or over the soil and by soil carried on farm implements.

Distribution.—Red stele is common throughout the northern two-thirds of the country. It has also been found as far south as Georgia and Arkansas.

Symptoms and damage.—The symptoms that positively identify this disease are found in the center (or stele) of the root. In a normal root, both the center and the part surrounding the center are yellowish white. In a plant with red stele, the center is a distinctive brownish red, which contrasts with the normal yellowish white of the part around it. The red color may extend the length of the root to the crown, or it may show only a short distance above the dead tip. It usually does not extend into the crown of the plant; pronounced discoloration of the crown has some other cause.

PN-5848

Plant at right infected with red stele. Compare with normal plant, left. Note that infected plant lacks small feeding roots.



PN-5849

Roots at left and center infected with red stele; roots at right normal. Note dead tips on roots at left. Roots in center are split lengthwise to show reddened core. Roots at right are split to show normal white center.

The red center is best seen during the spring, up to the time of fruiting. Later in the season it may disappear as the rotted roots are replaced with new ones.

Other symptoms that should make you suspect red stele are: Poor growth and frequent wilting of plants, especially those in low, wet areas of the field; younger leaves that have a bluish-green cast; older leaves that turn yellow or red. When dug, some of the roots of diseased plants have a rattail appearance—unbranched with black tips or black patches.

Plants infected with red stele are stunted. They wilt in dry weather. Often they die just before the fruit starts to ripen. In diseased plants that do not die, symptoms disappear during warm summer weather. These plants may recover and produce a few worthless fruits, but symptoms usually recur in the late fall or the following spring.

Red stele may infect only a few plants in low areas of the field. Or it may be distributed throughout a field or strawberry-growing region. It is most destructive in heavy or poorly grained soils that are saturated with water in cool weather when the fungus is active; the swimming spores move through this free water to attack the plants.

What to do if the disease occurs.—At present there are no chemical or cultural treatments that will assure a normal crop in an infected planting. The only practical control for red stele in fields infested with the fungus is to replant with red stele-resistant varieties. There is no practical treatment or crop rotation that will rid the soil of the fungus, and the fungus can persist for years once the soil becomes infested.

Resistant varieties grown on infested soil should be rotated with other crops. If a resistant variety is grown continuously on infested soil, there is a good chance that a new, more virulent race of the fungus to

which the variety is not resistant—will appear. The chance that this will happen is reduced, but not removed, by crop rotation.

Resistant varieties introduced so far (1975) are Columbia, Darrow, Earliglow, Olympus, Rainier, Shuksan, Guardian, Hood, Marshall, Midway, Molalla, Redchief, Redcrop, Sunrise, Surecrop, Temple, Totem (Canada), and Vermilion. Some of these that are adapted to conditions in particular areas of the country are of poor quality when grown elsewhere. Others (Midway, Sparkle, and Surecrop, for example) are widely adapted. Some are such recent introductions that their values are not yet known.

New races of red stele fungus that can damage some of the resistant varieties have recently appeared in several areas. Guardian, Redchief, Sunrise, and Surecrop carry resistance to the races that are known in the East. Hood, Molalla, Olympus, Rainier, Shuksan, Totem, and Siletz carry resistance to several races that occur in the West.

Prevention.—Avoid, if possible, setting infected planting stock. Look roots over carefully to see if any have the rattail appearance that may indicate red stele. Cut any suspicious roots to see if there are typical red stele symptoms. State plant-inspection services cannot identify every shipment that contains red stele-infected plants because the distinctive red center that positively identifies this disease may not be present at the time of inspection, or only a few plants from a nursery field may be diseased.

Avoid planting any but resistant varieties in infested land.

Verticillium Wilt

The fungus that causes this disease lives from year to year in the soil. Besides strawberries, many other common crops and several kinds of weeds are also hosts of this fungus.

Distribution.—Verticillium wilt occurs throughout the United States.

Symptoms and damage.—The fungus is most active during cool weather. In new plantings, symptoms appear about the time runners begin to form. In established plantings, symptoms appear about the time fruit begins to ripen.

Outer leaves wilt and dry at the margins and between the veins; they become dark brown. Few, if any, new leaves develop. New roots that grow from the crown often are very short and have blackened tips. Plants appear to be dry and flattened. Black sunburn lesions may appear on leafstalks and runners. Severely affected plants collapse, sometimes abruptly. Less severely affected plants are unproductive. In the East, less severely affected plants usually recover and produce normally the next year. In the West, affected plants usually do not recover.

The disease will often appear in mother plants but not in rooted daughter plants. Thus, it is more obvious when strawberries are grown in hills than when they are grown in matted rows.

Some of the most susceptible varieties are Daybreak, Dixieland, Earlidawn, Jerseybelle, Klondike, Lassen, Molalla, Northwest, Raritan, Shasta, and Vesper. Varieties that have some resistance are Blakemore, Catskill, Empire, Fletcher, Gaia, Guardian, Hood, Howard 17 (Premier), Marshall, Redchief, Robinson, Salinas, Siletz, Sunrise, Surecrop, and Vermilion.

Prevention.—In the East, allow 2 years between tomatoes, peppers, or potatoes and strawberries.

In the West, do not grow susceptible strawberry varieties on land that has a history of having been planted to tomatoes, peppers, potatoes, cotton, okra, melons, eggplant, mint, apricot, almond, pecan, cherry, avocado, roses, or cane fruit. The verticillium wilt fungus has been known to persist in the soil in the Pacific States for more than 10 years.

In areas where verticillium wilt is a major problem, consider a variety of strawberry that has some resistance to this disease.

Fumigation of the soil with chloropicrin, frequently with methyl bromide added for weed control, has given good results, but the cost ranges from $200 to $600 per acre.

Black Root-Rot

Black root-rot is the general name for several root troubles that produce similar symptoms.

The cause of black root-rot is not known, but one or more of the following may be partly responsible: Soil fungi, nematodes, winter injury, fertilizer burn, drought, and too much salt, water, or alkali in the soil.

Distribution.—Some form of black root-rot has been found in every strawberry-growing area. The injured plants may be scattered through the planting or grouped in one or more parts of it.

Symptoms and damage.—To be able to recognize the symptoms of black root-rot at various stages of the root's development, it is necessary to know what a normal root looks like at each stage.

Newly developed main roots of a normal strawberry plant are pliable and almost white. After several months they generally become woody and are dark brown to black on the surface. When this dark surface is scraped away, a yellowish-white living core can be seen. Small feeder roots that branch out from the main roots are white as long as they are active.

Roots of a plant with black root-rot have one or more of the following symptoms:

- Root system much smaller than in normal plants.
- Main root spotted with patches or zones that are darker than the rest of the root.
- Feeder roots lacking, or feeder roots spotted with dark patches or dark zones.
- All or part (usually the tip) of main roots killed. A cross section of a dead root shows it blackened throughout.

Plants with black root-rot are less vigorous than normal plants and produce fewer runner plants. Those with severe root-rot may die.

Control.—Use only healthy white-rooted plants. No other general recommendation for reducing losses from black root-rot or from preventing it can be given. Your county agent or State experiment stations may be able to suggest measures for controlling it that have been successful in your area.

Nematode Infection

Nematodes are worms too small to be seen easily by the unaided eyes. Many species live in the soil. Several of these attack strawberry roots,

several others attack the plant above ground.

Two species that attack strawberry roots—namely, the northern root-knot nematode and the root lesion nematode—enter the roots to feed. The sting nematode and several others feed only on the surface of the roots.

Nematodes that enter the roots to feed can stay alive in the roots when plants are dug, stored, and shipped—even if they are shipped barerooted. Nematodes that feed on the surface of the roots usually are dislodged when the plants are dug and the soil is removed from the roots.

Most root nematodes are more destructive in sandy soils than in clay soils.

PN-5850

Roots infected with the northern rootknot nematode. Note swellings and branch roots above each swelling.

Northern root-knot nematode

The northern root-knot nematode is the only species of root-knot nematodes that attacks strawberry plants. It also attacks many other plants and common weeds; it does not attack most grains and grasses.

Distribution.—Much cropland in the northern two-thirds of the country is infested with the northern root-knot nematode. It is found in the South only where it has been introduced on strawberry plants or where peanuts have been grown extensively.

Symptoms and damage.—These nematodes form swellings (or galls) on the roots. Swellings range in size from minute to about 1/4 inch in diameter, averaging 1/8 inch in diameter. Usually there are several short branch roots just above the swelling.

A severe infection has the same effect on the plant as removing most of the roots: Plants are weakened, are more subject to drought injury, and make fewer runner plants; therefore, they produce less fruit. Damage usually becomes more severe as the nematode population on the plant increases during the second and later fruiting years.

What to do if plantings are infected.—Practice very shallow cultivation to keep roots from further damage. Eliminate weeds. Maintain high soil fertility. Irrigate during dry periods.

Prevention.—Plant only stocks that are free of root knot. This is important because infested strawberry plants may carry nematodes into land where they do not now occur.

Many nurseries now treat their plants to free them of root knot. Several State quarantine services intercept plants that have root galls. Some of these services do not allow root-knot infected plants to be shipped into the State or into specified areas. Others allow the plants to be shipped in, but warn the buyer that the plants are infected.

If strawberries must be planted in soil that is heavily infested with root-knot nematodes, it may be profitable to fumigate the plot or field.

SOIL FUMIGATION

Before Planting

Nematocides will, if applied to the soil properly, kill a high percentage of most nematodes that attack strawberries. Most fumigants must be applied at least 3 weeks before planting time. Because the toxic gas they give off will kill plants as well as nematodes, this gas must be out of the soil before the strawberries are set.

Usually a grower will prefer to use a soil fumigant first on only a part of the land to see if increased yields justify the expense. If other conditions are favorable, yields will increase markedly the first year. Although the few nematodes that remain after fumigation can increase in number rapidly, the beneficial effect of fumigation may last throughout the life of the strawberry planting.

Before applying soil fumigants to a field, consult your county agents or State agricultural experiment station for suggestions concerning materials to use.

In general, successful fumigation before planting consists of careful preparation of the soil and application of a correct amount of fumigant to the proper soil depth with special equipment. The fumigant should be applied only when soil temperature measured at a depth of 6 inches is between 50° and 80° F. Soil should be neither waterlogged nor dry at the time of application. Plants should not be set sooner than recommendations of the manufacturer as stated on the label.

In Established Plantings

The material dibromo chloropropane has been used with good results to reduce root knot and sting nematodes on established strawberry plantings. It is applied as a side dressing at rates recommended by the manufacturer.

Precautions

Soil fumigants are poisonous. Handle them in accordance with the manufacturer's directions on the package. Do not breathe the fumes.

Never risk getting the liquid into the eyes or mouth. Do not allow the liquid to stay on the skin; wash it off promptly with soap and water. If liquid is spilled on shoes, gloves, or other clothing, remove the clothing without delay, and do not wear again until thoroughly aired or cleaned.

Whether a field is fumigated or not, a high organic level in the soil appears to reduce nematode damage.

Root-lesion nematode

Several species of root-lesion nematodes attack strawberries. One or more of these can also attack most other cultivated crops, most trees and ornamentals, and many weeds. This is one of the nematode groups that may be a cause of black root-rot.

Distribution.—Root-lesion nematodes that attack strawberries infest most cropland in the United States.

Symptoms and damage.—If infection is severe, young roots may become wiry and brown. Plants may be stunted and less vigorous, less productive, and more easily damaged by drought than uninfected plants. If infection is not severe, damage usually is not serious.

Severe infections occur only when the root-lesion nematode population in the soil is high.

What to do if plantings are infected.—Keep root damage to a minimum by very shallow cultivation; eliminate weeds; maintain high soil fertility; and irrigate during dry periods.

Prevention.—Plant stock that is substantially free of root-lesion nematodes. Clean white roots indicate that few or no root-lesion nematodes are present.

If strawberries must be planted in soil that is heavily infested, soil fumigation is recommended.

Sting nematode

The sting nematode has been injurious to strawberries only in Florida and other Southeastern States. It also attacks several other crops.

Symptoms and damage.—Outer surface of the roots has dark spots or is entirely brown. Small roots are killed.

If infection is severe, the plant becomes stunted and weak; leaf margins turn brown. Some plants die. Often only a part of a planting is noticeably affected.

What to do if plantings are infected.—If many plants are severely infected, plow up the planting. The yield will not warrant the time and effort needed to cultivate and harvest the crop.

Prevention.—Plant stock that is substantially free of sting nematodes. Plants from a field infested with these nematodes will carry them if soil remains on the roots. To remove this nematode from infected plants, wash soil off the roots with water.

If strawberries must be planted in soil that is infested with the sting nematode, row or broadcast application of a soil fumigant is recommended.

FOLIAGE, BUD, AND FLOWER DISEASES

The most serious diseases that attack the aboveground parts of the plants are four fungus leaf diseases, bud rot (also caused by a fungus), and nematode infection.

Three of the leaf diseases—leaf spot, leaf scorch, and leaf blight—cause little or no damage in dry or irrigated areas. The fourth, powdery mildew, is seldom a problem except in some cool, irrigated areas or when very susceptible varieties are grown.

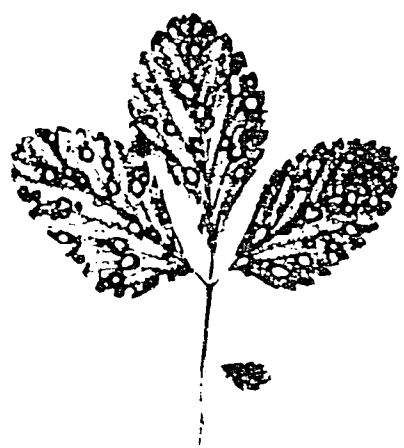
Leaf Spot, Leaf Scorch

Leaf spot and leaf scorch do about the same kind of damage and are spread in the same way. Methods of control are the same for both. Often both diseases occur on the same plant; they are sometimes mistaken for different stages of the same disease.

Each disease is caused by one particular fungus. Neither fungus is known to attack any other field or garden crop. Each usually is brought into a field when new plants are set or may be carried in from nearby fields by birds or insects, by farm implements, or on the hands and clothing of workmen.

Both fungi live through the winter on infected plants. Cool weather and an abundance of moisture favor their spread.

Both fungi attack leaves, leafstalks, fruitstalks, runners, and caps. The leaf spot fungus will infect these parts only when they are immature. The leaf scorch fungus will infect leaves at all stages of development.



PN-5851

Leaf spot infection as it appears on upper side of leaves. Spots are purple with white centers.

The leaf spot fungus also causes black-seed of berries. The leaf scorch fungus occasionally attacks berries but causes little damage. It is not noticeable except when it shows on green berries; then it appears as a red or brown discoloration or flecking of the surface.

Distribution.—Epidemics of leaf spot and epidemics of leaf scorch occur each year in some sections of the Gulf Coast region. In other regions, scattered epidemics occur from time to time.

Symptoms.—Early symptoms of the two diseases are similar. Differences appear as the diseases progress.

In *leaf spot*, round purple spots 1/8 to 1/4 inch across can be seen on the upper side of the leaves. At first the whole spot is purple. Later, the center of the spot becomes tan or gray, then almost white; the border remains purple. On the underside of the leaves the spots show as indistinct tan or bluish areas.

If other parts of the plant are attacked, they are marked by spots like those on the upper side of the leaves.

In *leaf scorch*, small dark-purple spots up to one-fourth of an inch in diameter appear on the upper side of the leaves. These spots never have light centers as do those of leaf spot and they have a more irregular outline. If spots become so numerous that they cover most of the leaf, the leaf dries up and looks scorched.

Similar spots may appear on other affected parts of the plants.

PN-5852
Leaf scorch as it appears on upper side of leaves. Spots are dark purple.

Leaf spot damage.—A severe attack of leaf spot kills so many leaves that the whole plant is weakened or killed.

Whether a trace of leaf spot in a field is likely to cause much damage if left uncontrolled depends on the variety being grown and on weather conditions at the time new leaves are developing.

Several strains of the leaf spot fungus are known, which affect varieties differently. In general, the manner in which varieties react is as follows:

Florida Ninety, Marshall, Raritan, Sparkle, Sunrise, and Vesper varieties are very susceptible to leaf spot. Dixieland, Dunlap, Jerseybelle, Midway, Pocahontas, Redchief, and Vermilion are moderately susceptible. Blakemore, Catskill, Earlidawn, Robinson, and Surecrop are only slightly susceptible. Albritton, Apollo, Atlas, Daybreak, Earlibelle, Fairfax, Headliner, Howard 17 (Premier), and Midland are resistant.

If there are frequent rains during early spring, a few leaf-spotted plants can start an epidemic. Clusters of spores emerge from the white centers of the spots. Rain scatters them to nearby leaves; there they germinate and start new spots. A spring application of nitrogenous fertilizer can increase the amount of the disease because it increases the amount of young leaves at the time when leaf spot is most likely to occur.

Leaf scorch damage.—A severe leaf scorch attack may kill so many leaves that the whole plant is weakened or killed. Leaf scorch also often does considerable damage to caps, leafstalks, runners, and fruitstalks as well as to the leaves. Scorch spots may girdle the fruitstalks, causing the death of flowers and young fruit.

Whether leaf scorch is likely to cause much damage in a field if left uncontrolled when found on only a few plants depends on the variety and on weather conditions during early spring and fall. In hot, dry summer months there is little spread of leaf scorch.

Varieties that are susceptible to leaf scorch are Armore, Dixieland, Earlidawn, Florida Ninety, Jerseybelle, Klondike, Midway, Pocahontas, Redglow, Tennessee Beauty, and Vesper. Moderately susceptible varieties include Fairfax, Raritan, Robinson, Sparkle, and Surecrop. Resistant varieties are Albritton, Apollo, Atlas, Blakemore, Catskill, Earlibelle, Fletcher, Howard 17 (Premier), and Redstar.

What to do if disease occurs.—The fungicide sprays discussed under "Prevention," below, can be used to control both diseases.

Prevention.—Frequent renewal of strawberry fields helps prevent epidemics of leaf spot and leaf scorch. A new field in which disease-free plants are set will remain reasonably free of these diseases for the 1 to 3 years it is usually cropped.

The use of resistant varieties, if they are adapted to the growing conditions in your area, may also help. For further information, see Farmers' Bulletin No. 1043, "Strawberry Varieties in the United States." Copies of this publication may be purchased from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, or from any U.S. Government Printing Office bookstore across the country. Write to Superintendent of Documents for price information. Be sure to include your return address and ZIP code.

In areas where the fungi of the two diseases are present in quantity, a spray program may be profitable. Spray a new bed at monthly intervals during the spring and fall of the first year with bordeaux mixture, basic copper sulfate, or such organic materials as thiram, zineb, dyrene, or captan. In the spring before fruiting, one or two sprayings are generally sufficient. Observe limitations on use of these fungicides given in the fungicide chart.

Leaf Blight

Leaf blight is generally less troublesome than leaf spot or leaf scorch. It may be a problem in cooler strawberry-growing areas. The fungus that causes it lives through the winter on infected plants and is spread in the same ways as leaf spot.

Symptoms and damage.—Red to brown spots may be seen on the leaves. Spots have a purplish border, are from 1/4 inch to more than 1 inch across, and are oval or triangular in shape.

Leaf blight is found most often on older plants after harvest. It seldom damages these plants seriously unless they are less vigorous than normal. It seldom damages young runner plants.

Among varieties most susceptible to this disease are Catskill, Dunlap, and Robinson. Earlidawn, Empire, and Howard 17 (Premier) seem to have some resistance.

What to do if the disease occurs.—The fungicide sprays recommended for prevention of leaf spot and leaf scorch can be used to control leaf blight.

Prevention.—Frequent renewal of strawberry fields may help prevent epidemics of leaf blight. If susceptible varieties are grown, a late summer fungicide spray may be profitable.

PN-5851
Leaf blight as it appears on upper side of leaves. Spots are red to brown, with a purplish border.

Powdery Mildew

Powdery mildew occasionally becomes severe in the Pacific Northwest. It causes damage in other parts of the United States only when there are extended periods of cool weather during the growing season.

Among varieties most susceptible to this disease are Armore, Apollo, Earlibelle, Jerseybelle, Lassen, Midland, Northwest, Redglow, Shasta, and Tennessee Beauty. Some of the most resistant are Catskill, Dunlap, Empire, Pocahontas, Siletz, Sparkle, and Sunrise.

Symptoms.—The most conspicuous symptom of mildew is an upward rolling of the edges of the leaves. Also, a thin white growth of cobweblike mold appears on the lower surface of the leaves and on stems and fruit. If attack is severe, leaves may show purple blotches or they may be killed.

What to do if disease occurs.—Sulfur dust can be used to control powdery mildew. The material, however, can severely injure leaves and flower stalks if the weather turns hot. Sulfur may be applied up to the time of full bloom and again, if necessary, after harvest.

If disease is severe, avoid overhead irrigation.

Prevention.—In localities where mildew is a problem, avoid planting strawberries in places that are shaded or have poor air drainage. No spray or dust program is generally recommended.

Bud Rot

Bud rot is caused by a fungus that attacks leafbuds and flowerbuds. It is easily mistaken for spring dwarf; both diseases have similar symptoms and appear at the same time of year.

PN-5854

Powdery mildew has caused leaves of these plants to roll up.

PN-5855

Bud rot: Plant at left infected, plant at right normal. Both plants are the same age.

There is no known way to prevent bud rot. It is less likely to occur, however, if plants are set at the correct depth and if the soil is not piled up around plants during cultivation.

Distribution.—Bud rot occurs throughout the United States. Apparently the fungus that causes it is common in field soils. The disease is most likely to develop during cool, wet spring weather. Sometimes, plants stored at improper temperatures or those weakened in other ways in storage or shipment show a high percentage of bud rot when planted.

Symptoms and damage.—The most noticeable symptoms appear during the blossoming period. The fungus slows the development of crown buds, or kills them. The outer leaves assume a horizontal position and become darker green than normal. A few new leafbuds soon develop under what is left of the original buds; these may also be killed, or they may survive as weak, spindly growths. Some plants are killed; usually, however, infected plants recover but produce no fruit that year.

Bud rot can be distinguished from spring dwarf in two ways. Plants infected with bud rot are not grouped together in a field, those with spring dwarf are. Bud rot-infected plants show rotting of leafstalks and dead or decaying bud tissues in the crown, decayed tissues are less likely to occur in plants with spring dwarf.

Nematode Infection

Three species of nematodes attack strawberry plants above ground. One causes spring dwarf, one causes summer dwarf, and one damages leafstalks, fruitstalks, and new leaves.

Spring dwarf, summer dwarf

Spring dwarf and summer dwarf are caused by closely related nematode species that live inside leafbuds. The nematodes feed by sucking the sap from the tightly folded leaves within the bud. The injury to the leaves results in dwarfing and other malformations that show after the leaves unfold.

Both diseases are most commonly spread through setting of infected plants. The spring dwarf nematode does not persist in the soil long enough to spread the disease from an old planting to a new planting. The summer dwarf nematode persists long enough to spread the disease from an old planting to a new planting made within a year.

The diseases may also be spread within a field or area by drainage of surface water if diseased plants are at higher levels in a field.

Neither disease is now found to any great extent in most strawberry-growing areas because of successful control efforts by nurserymen and growers. Either disease can, however, if not guarded against, gain a foothold in a field and quickly spread to cause great losses.

Distribution.—In the past, *spring dwarf* has caused serious losses in several areas in the Northeastern States. Although it is now a rarity, it is found from time to time in stocks in the Atlantic States from New England to Georgia, in Texas, Michigan, and in the Pacific States. The nematodes causing spring dwarf can live through winters with subzero temperatures and through relatively hot summers. They become inactive in extremely hot summers and may die out during long, hot growing seasons.

Summer dwarf has caused damage from Virginia and Arkansas southward and in southern California. However, there is only an occasional field that has enough infected plants to reduce the yield. The nematode that causes this disease can live through mild winters as far north as southern Illinois and Delaware.

Symptoms and damage.—Symptoms of *spring dwarf* show best during the early part of the growing season, when the greatest damage is done. Leaves that develop from infected buds are narrow, twisted, and glossy. There are few or no blossom buds; therefore infected plants produce little or no fruit. Some plants are killed during the spring, but most infected plants survive. When hot summer weather brings a decrease in the number of spring dwarf nematodes, the infected plants seem to recover; they produce normal-appearing runners. Most of these runners are infected and will show symptoms the following spring.

Plants infected with *summer dwarf* show symptoms on leaves that develop during the summer and early fall. The summer dwarf nematodes are present in buds in the spring, but do not build up to destructive populations until warm weather.

Affected leaves are narrow, twisted, glossy, stiffer and greener than normal, and have shorter than normal stalks. Some leaves are very small. The malformed leaves are in the center of the plant, surrounded by normal or nearly normal leaves that were formed earlier. Leaves that develop in cooler fall weather may be almost normal in both size and shape. Infected plants form fewer flowerbuds than normal. Fruit is sometimes misshapen. Most runner plants are infected.

What to do if dwarf occurs.—Take out and destroy diseased plants. Prevent drainage water from carrying nematodes to uninfected plants in the fields.

Prevention.—Plant only stock that is free of dwarf nematodes. If you obtain plants from your own field or from a neighbor, avoid those from fields that you know or suspect are infected.

Most nurseries, because of careful selection of stock, are free from those and other foliar nematodes. In most States, plants with any foliar nematodes cannot be certified by plant inspectors.

PN-5856

Spring dwarf: Plant at left infected, plant at right normal. Both plants are the same age.

Bulb and stem nematode

The bulb and stem nematode, a serious pest of clovers, sometimes attacks strawberries. It has appeared most frequently in the Pacific Northwest—usually in fields in which the pest has attacked previous crops or near infected plantings of clover.

Symptoms are short, abnormally thickened leafstalks and fruitstalks, and distorted leaves. Plants may be severely stunted and unproductive. Symptoms usually appear only on parts of the plant that develop early in the season. The disease is most severe during a cool, wet spring.

If only a few plants in a field are infected, remove and destroy them.

To prevent infection with this nematode, do not plant strawberries

near or in soils that have a history of this nematode on other crops. Do not use plants from diseased fields in new plantings.

BERRY DISEASES

Fruit Rots

Six fruit rots—gray mold rot, tan rot, hard rot, leather rot, blackseed, and stem end rot—are found in the field.

Each is caused by a different species of fungus. Gray mold rot causes the most damage, black-seed the least. Most of the fruit rots are especially troublesome in the South.

Long periods of rain and cloudy weather accompanied by temperatures favorable to one or more of the rot fungi usually precede epidemics of fruit rot.

Preventive measures are the same for all the fruit rots except stem end rot.

Gray mold rot

Gray mold rot occurs throughout the United States. It is found on berries at all stages of their development.

Symptoms and damage.—Gray mold infection often starts on blossoms and green fruit—where there are frost or other injuries to the flowerstalks or caps, or where dead petals adhere to the developing fruit. Sometimes it affects flowerstalks enough to prevent development of the fruit.

Infection also may start in the part of a berry that touches the ground, another decayed berry, or a dead leaf. At first it shows as a light brown, rather soft spot. The rot spreads throughout the berry. As the berry

PN-5857

Gray mold on unripe berry.

dries out it becomes firm and tough, is a uniform brown color throughout, and is covered by a distinctive gray powder or a dusty-appearing growth.

What to do if disease occurs.—Some fruit may be saved by fungicide sprays (discussed under "Prevention") once the rot is noticed.

Prevention.—Proper spacing of plants and correct timing of fertilizer application are the most important preventive measures.

If plants in matted rows are not densely spaced or if the rows are kept narrow, the developing fruit can dry more rapidly and thus be less subject to rot than if the plants are allowed to become crowded.

Apply any fertilizer in fall or summer rather than in spring. Fertilizer applied in the spring produces thick foliage; shading by thick foliage prevents rapid drying of berries after rains and heavy dews; this helps form suitable conditions for development of rots.

Mulching (with straw, pine needles, or other materials), when practical will also help reduce the damage from fruit rot; the fungi that cause fruit rots live in or on the soil and in infected leaves and plant debris. Whether plants are mulched or not, cultivate as little as possible from bloom until after harvest.

Another control measure—spraying or dusting with fungicides—probably will reduce the amount of rot damage except when conditions are extremely favorable to the growth of rot fungi. This control measure often costs more than it is worth, however.

Spray with benlate, captan, ferbam, zineb, or dyrene as soon as blossom buds are visible in the spring. Spray every 2 weeks until the berries are one-third grown. After this time, spray only if rot is present or if extensive cool or rainy periods are predicted. Observe limitations on use of these fungicides given in the fungicide chart.

Tan rot

Tan rot occurs in the Southern States. It attacks both green and ripe berries.

Symptoms and damage.—Tan rot forms slightly sunken, tan-colored areas on the berry surface; these usually develop on the sides of the berries. As the rot extends into the berry, the rotted part widens and forms a cone. This can easily be removed in one piece with the point of a knife or pencil.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Hard rot

Hard rot occurs throughout the United States. It has been most serious in central Florida. It attacks only ripe berries.

Symptoms and damage. Hard rot usually attacks only berries that touch the ground as they grow. Affected berries generally are one-sided and show a hard brown area on the side that touched the ground. There is a distinct line between the rot and the rest of the berry. The rest of the berry remains unchanged in appearance and in taste.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Leather rot

Leather rot occurs in Alabama, Louisiana, Mississippi, Arkansas, Missouri, Tennessee, Kentucky, Illinois, Maryland, and Virginia. It attacks both green and ripe berries.

Symptoms and damage.—On green berries, diseased areas are either dark brown or natural green outlined by a brown edging. On partly colored berries, diseased areas are light brown at the center and shade into purple at the edges. On fully ripe berries, there may be no change in color or a slight darkening of the diseased area.

The healthy flesh of a berry that is even slightly rotted has a bitter taste.

If a diseased berry is cut across, there is no clear line separating diseased and healthy flesh. However, there is a marked darkening of the water-conducting system leading to each seed. In the later stages of decay, the fruit becomes tough and leathery.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Same as for gray mold rot.

Black-seed

Black-seed occurs most often in the South Atlantic States. It occurs less frequently in other areas where leaf spot is severe. It appears only on ripe berries.

Symptoms and damage.—Black-seed forms black spots about one-fourth of an inch in diameter surrounding groups of seeds on the surface of the berries. The berry pulp is discolored a short distance below the black surface, but there is no general decay of an infected berry. Usually only 1 or 2 spots occur on one berry, but occasionally there are as many as 8 or 10.

What to do if disease occurs.—Same as for gray mold rot.

Prevention.—Spray a new bed at monthly intervals during the fall of the first year with bordeaux mixture, basic copper sulfate, or such organic materials as zineb and captan. Observe limitations on use of these fungicides given in the fungicide chart. Other preventive measures are the same as for gray mold rot.

Stem end rot

Stem end rot is sometimes destructive in Michigan and other cooler strawberry growing areas. It attacks green or ripening fruit, and is especially severe on berries of the Robinson variety.

This rot is caused by a fungus that is similar to the fungus that causes leaf blight.

Symptoms and damage.—Stem end rot usually attacks the cap first, then moves into the pulp. The cap becomes dry and brown; the pulp soft, brown, and watery. There is a distinct line between diseased and healthy tissue.

What to do if disease occurs.—Same as for gray mold rot.

Brown Caps

When caps are killed and dried out, they turn an unattractive brown. Although this cap discoloration does not affect the taste of the berry, berries with brown caps bring a lower price than those with bright green caps.

The most common causes of brown caps are the fungi that cause the various fruit rots.

A combination of high temperature and low humidity, especially when accompanied by wind, can kill berry caps. Strawberries of Klondike, Missionary, and Blakemore varieties have weak caps that are easily killed by such weather conditions.

Prevention.—Spraying or dusting with the fungicides recommended for the prevention of gray mold rot will often reduce the amount of brown caps.

FUNGICIDES USED FOR STRAWBERRY DISEASE CONTROL

The fungicide chart gives a range in amounts of fungicide that can be applied to strawberries to control the diseases discussed in this bulletin.

The lowest rate given will control the disease specified, under some conditions. Also, use of strawberry varieties that are resistant but not immune to diseases will reduce the rate of application or number of fungicide applications required.

Choice of a higher rate of application may be necessary for any of the following reasons:

Climate.—Areas or seasons with high rainfall or frequent dews and cloudy days may require an increased rate of application or more applications with the minimum rate.

Prevalence of a disease.—Frequent applications with a higher rate may be needed to check a severe outbreak of a disease.

Density of planting.—Excessive foliage growth or overly thick beds may require higher rates for fruit rot control.

Experience of the growers.—Local conditions (climate, diseases, or varieties used) may result in local recommendations of a rate above the minimum.

Application equipment.—Low efficiency sprayers (with low pressure, large droplet size, or poor distribution pattern) may require higher rates of application to achieve the proper coverage of foliage.

Soil fumigation rates.—Heavy or muck soils may require more material than the minimum rate. Local experience will determine the rate of application needed.

The table also gives limitations in application of the fungicides. These must be followed with all rates of application.

Read the precautions in this bulletin on the use of pesticides.

Fungicide	Used to control	Range in rates of application per acre[1]	Limitations
Benlate[2]	Fruit rots, leaf fungi, powdery mildew	0.25 - 0.5 pounds	Can be used any time
Bordeaux mixture	Leaf fungi	0.75 to 2.6 pounds (as metallic copper equivalent) applied 3-3-100[3] to 8-8-100[4]	None when used in accordance with accepted agricultural practices
Captan	Fruit rots, leaf fungi	1.0 to 4.0 pounds	Can be used any time
Chloropicrin	Verticillium wilt	320 to 1,000 pounds or 175 pounds with 140 pounds methyl bromide	Wait 1 to 2 weeks after application before planting. Disk or aerate soil between time of application and planting.
Copper sulfate (basic)	Leaf fungi	0.75 to 4.0 pounds (as metallic copper equivalent)	Same as for bordeaux mixture.
Dichlone	Fruit rots, leaf fungi	0.2 to 0.4 pounds	Do not use within 3 days of harvest.
Dyrene[2]	Fruit rots, leaf fungi	1.0 to 3.0 pounds	Do not use within 5 days of harvest.
Ferbam	Fruit rots, leaf fungi	1.0 to 3.0 pounds	Do not use within 14 days of harvest.
Sulfur	Mildew	1.0 to 5.0 pounds (if sprayed); 10 to 20 pounds (if dusted).	Same as for bordeaux mixture.
Thiram	Fruit rots, leaf fungi	1.25 to 3.25 pounds	If applied within 3 days of harvest, remove residue by washing.
Zineb	Fruit rots, leaf fungi	1.0 to 2.5 pounds	Do not use within 7 days of harvest.

[1]Given as amounts of 100 percent of the active ingredient unless otherwise indicated.

[2]Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

[3]Use 3 pounds copper sulfate (bluestone), 3 pounds hydrated lime, and 100 gallons water.

[4]Use 8 pounds copper sulfate, 8 pounds hydrated lime, and 100 gallons water.

Disease	*Causative Agent*
Red stele	Phytophthora fragariae
Verticillum wilt	Verticillium albo-atrum
Leaf spot	Mycosphaerella fragariae
Leaf scorch	Diplocarpon earliana
Leaf blight	Dendrophoma obscurans
Powdery mildew	Sphaerotheca macularis
Bud rot	Rhizoctonia sp
Gray mold rot	Botrytis cinerea
Tan rot	Pezizella lythri
Hard rot	Rhizoctonia sp
Leather rot	Phytophthora cactorum
Black-seed	Mycosphaerella fragariae
Stem end rot	Gnomonia fructicola

Nematode	*Scientific Name*
Northern root-knot nematode	Meloidogyne hapla
Root-lesion nematode	Pratylenchus spp.
Spring dwarf	Aphelenchoides fragariae
Summer dwarf	Aphelenchoides besseyi
Sting nematode	Belonolaimus spp.
Bulb and stem nematode	Ditylenchus dipsaci

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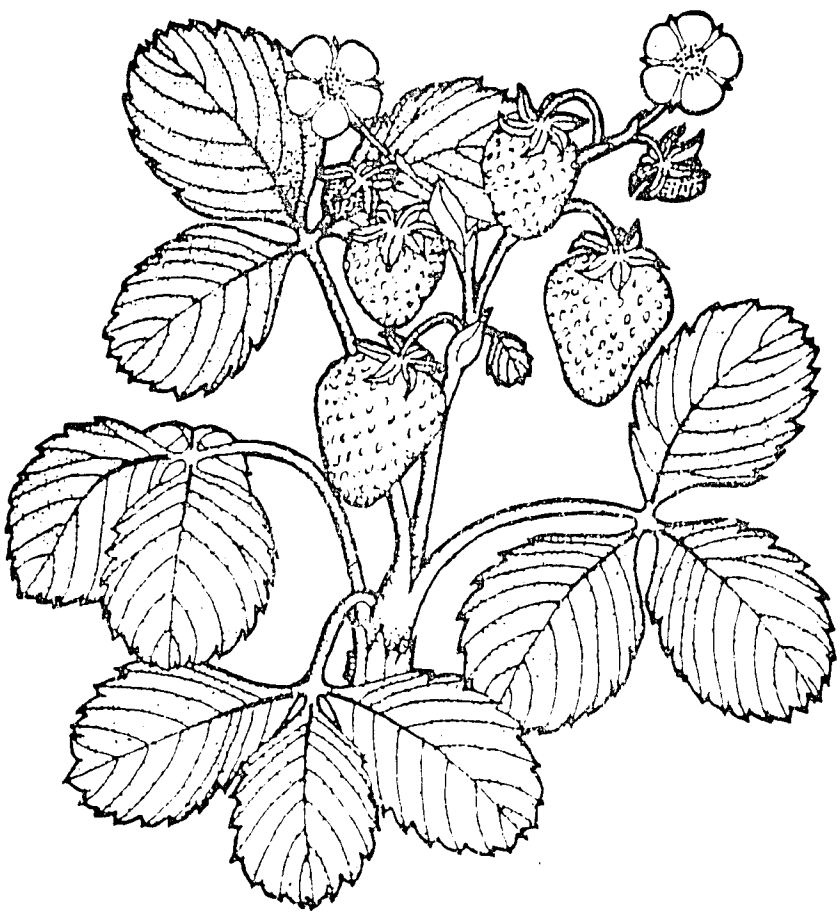
COMMERCIALLY GROWN STRAWBERRIES

insect, disease, and weed control guide for Washington state



Cooperative Extension College of Agriculture Washington State University Pullman, Washington

DISEASE AND INSECT CONTROL GUIDE

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
PREPLANT TREATMENT				
Nematodes (occasional)	DD Telone Vidden D Vorlex	Follow manufacturer's directions.	Preplant only	Have nematode analysis made and base fumigation on results. It is best to fumigate in late summer or early fall before *anticipated planting in spring.*
Strawberry root weevil Black vine weevil Rough strawberry root weevil (common) Woods weevil Obscure root weevil (common)	No chemicals registered for preplanting application. See post-harvest period.			
Garden symphylan (rare)	fonofos (Dyfonate)	2 qt of 4 EC 20 lb of 10% granules		Apply Dyfonate to the soil just prior to planting. Disc into soil. Will protect plants only during summer following transplanting. Fumigation as explained above for nematodes, may be used.
ESTABLISHED PLANTINGS—HARVEST YEARS				
Dormant & Prebloom Periods				
Leaf Spot (common)	Bordeaux or Benomyl*** (Benlate)	6-6-100 1/2-1 lb of 50% WP (Apply in 100 gal water)	See remarks See remarks	*Do not* combine Bordeaux with insecticides or other fungicides. Where leaf spot has been a problem, make initial application when growth begins and repeat at 10-14 day intervals. If Bordeaux is used, discontinue at first bloom. Fruit rot program helps control leaf spot.

NOTE: All recommendations are made as formulations (the way it comes in the package); not to be confused with recommendations as active ingredient (actual pesticide) as may appear in other more technical publications.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
Powdery mildew (common)	benomyl*** (Benlate)	1/2-1 lb 50% WP applied in 100 gal water.	See remarks	Begin applications in early spring and discontinue well before harvest. Sulfur dust may burn foliage in hot weather. Plant damage has been reported from northwest Washington at rates of sulfur above 2 lb/100 gal. Consult fieldman for processor regulations.
	or sulfur dust	20-30 lb	See remarks	
	or sulfur spray	4-6 lb applied in 100 gal water.	See remarks	
Spittlebug (common)	azinphos-methyl (Guthion)	1 lb of 50% WP	5	Apply when blossom clusters start to separate. Control is more difficult after the spittle masses are formed. Use 100 gal of water per acre.
	or endosulfan (Thiodan)	2/3 qt of 3 EC	4	
		1 qt of 2 EC	4	*WARNING: Do not apply Guthion during bloom because of hazard to bees.* Apply Thiodan in evening or early morning to avoid bee poisoning.
		1 lb of 50% WP	4	
Aphids: (common)	Aphid sprays involve a special schedule that is aimed at the control of virus spread. Read the remarks below and refer to detailed spray schedule on page 9.			
	Metasystox-R, Guthion, and diazinon are all recommended for strawberry aphid control. Thiodan may also be used, but in many areas strawberry aphids are resistant to it. Spraying should begin in early April and be repeated at 3- to 5-week intervals until at least September. The use of Metasystox-R in Washington is restricted to three applications per season. The third application must be applied after harvest. It is suggested that two of these be applied in April and May when the aphid is multiplying most rapidly. Fields should be watched closely, and when any aphids are again seen, the field should be resprayed.			
Cyclamen mite (rare)	endosulfan (Thiodan)	2/3 qt of 3 EC	4	Direct spray into crowns.
		1 qt of 2 EC	4	
		1 lb of 50% WP	4	Apply in 100 gal of water per acre.
				Apply in evening or early morning to avoid bee poisoning.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
		Bloom Period		
Fruit rot (common)	Captan	5 lb of 50% WP applied in 100 gal water.	0	Begin applications at first bloom and obtain good spray coverage.
	or			
Leaf spot (common)	benomyl*** (Benlate)	1/2-1 lb of 50% WP applied in 100 gal water.		Apply Captan at about 8-day intervals or after each rainy period, but no more than 2 sprays in any 6-day period.
	or			Apply Benlate at 10-14 day intervals.
	Ronilan	1 1/2-2 lb of 50% WP applied in at least 100 gal water	0	Apply Ronilan at about 8-day intervals or after each rainy period, but no more than 35 lb/acre/year. Under low disease pressure (drier weather) apply at 10-14-day intervals.
	or			
	Topsin-M***	3/4-1 lb of 70% WP applied in 100 gal water	1	Apply Topsin-M at 7 to 10 day intervals.
Omnivorous leaftier (occasional)	Methoxychlor	3 lb of 50% WP	14	Apply during first or second week of bloom. Reapply in 3 weeks if necessary.
	Guthion, Sevin, and other chemicals which would probably control this insect are not recommended during the bloom period because of their high toxicity to bees.			See Bee Poisoning section on page 2.
Aphids: (common)	See pages 5 and 9.			
Twospotted spider mite (common)	cyhexatin (Plictran)	2 lb of 50% WP	1	Good coverage of undersides of leaves is essential. Tedion is most effective when used against low mite populations as its main action is against eggs and miniature mites. Do not reapply Tedion within 35 days.
	or			
	dicofol (Kethane)	1 1/2 qt of 18 1/2% EC	2	
		1 1/2 lb of 35% WP	2	
	or			
	tetradifon (Tedion)	Use as manufacturer directs.	3	In some areas, mites may be resistant to Kethane or Tedion.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
		Harvest Period		
Fruit Rot (common)	Captan or Benlate or Ronilan or Topsin-M			See details under "Bloom Period."
Slugs (occasional)	metaldehyde	25-50 lb of 2.4% bait.	6	Apply when slugs appear and repeat as needed. Apply between the rows to avoid contaminating fruit or foliage. Bait must contain no other pesticide which would leave an illegal residue at harvest.
	Consult your fruit buyer before using metaldehyde. In areas with a history of problems with slugs, it may be helpful to bait around margins of the fields during the year of establishment to reduce migration into the fields.			
		Posthurvest Period		
Twospotted spider mite (common)	Same as in bloom-period. Serious damage is rare at this time.			
Cyclamen mite (rare)	Same as in prebloom period			
Aphids: (common)	See pages 5 and 9.			
Strawberry leafroller (occasional) (rare)	azinphos-methyl (Guthion) or	1 lb of 50% WP		Apply if population reaches two larvae per plant or foot of matted row.
	*parathion	1 pt of 4 EC 2 lb of 25% WP		See Bee Poisoning section on page 2.

CONTROL GUIDE (continued)

Disease or Insect and Relative Occurrence	Pesticide (use one)	Amount of Formulation Per Acre*	Minimum Days Between Last Application and Harvest	Remarks
Obscure root weevil (common)	azinphos-methyl (Guthion) or *carbofuran (Furadan)	1 lb of 50% WP 2 qt of 4 F		Apply Guthion in 100 gal water per acre to the foliage. Begin treatments immediately after harvest. Repeat in 2 weeks. Do not apply unless root weevils are definitely present. See below for Furadan application instructions.
Strawberry root weevils Black vine weevil Woods weevil (common)	*Furadan	2 qt of 4 F		Apply 2 qt of 4 lb/gal. flowable Furadan in 100 gal of water per acre. Concentrate in a 12-inch wide band over the rows. Incorporate by use of 1-2 inches of water through sprinklers. Application may be between last harvest and October 1, but it is recommended that it be applied approximately August 1. Do not apply if any berries are present. Do not apply more than once per season. (See WSU EM 4046 for additional information.)

* EC=emulsifiable concentrate; WP=wettable powder; F=flowable (see page 1).

** Registration of chlordane has been suspended for this use by EPA; however, existing stocks can be used according to label directions. No substitute is registered for preplant treatment. See postharvest period.

*** Certain fungi can build up resistance rapidly to Benlate or Topsin-M. Repeated applications of these fungicides should be avoided. Captan or Ronilan used as alternate sprays, or tank mixtures of Benlate plus Captan, or Benlate plus Ronilan, or Topsin-M plus Captan will reduce the possibility of resistance developing. Fungi resistant to Benlate are also likely to be resistant to Topsin-M, thus alternation or tank mixtures of these two fungicides is not suggested.

Spray Schedule for Strawberry Aphids in Established Strawberry Fields

Date[a]	Chemical[b,c]	Amount of Formulation Per Acre*	Min. Days Application to Harvest	Remarks
April 1-7	Metasystox-R	2 pts of 25% EC	3	*WARNING: Do not apply diazinon or Guthion during bloom because of hazard to bees.*
Just before bloom	Guthion	1 lb of 50% WP or 2 pts of 2S or 2L	5	
May 30 or Immediately after harvest	Metasystox-R	2 pts of 2S or 2L	3	
	Metasystox-R	2 pts of 25% EC	3	Apply Metasystox-R in evening or early morning to avoid bee poisoning.
	or Guthion	1 lb of 50% WP or 2 pts of 2S or 2L	5	
	or diazinon	1 pt of 4 EC or 1 lb of 50% WP		
Sept. 1-15	Metasystox-R	2 pts of 25% EC	3	Each of the listed chemicals is to be used at the rate of 1/2 pound of *actual toxicant* per acre.
	or Guthion	1 lb of 50% WP or 2 pts of 2S or 2L	5	
	or diazinon	1 pt of 4 EC or 1 lb of 50% WP	5	

[a] These dates are for Oregon and Clark County, Washington. Delay approximately 5-7 days for Pierce County and 10-14 days for Skagit and Whatcom Counties, Washington.

[b] All chemicals to be used at 0.5 lb of actual toxicant per acre. Formulations are given for growers' convenience and equal 0.5 lb actual toxicant per acre. If Plictran must be used for mites, combine with Guthion wettable powder, or apply a week after Metasystox-R.

[c] Do not apply Guthion or diazinon when blossoms are present in order to prevent bee poisoning. Apply Metasystox-R only in the evening when bees are not present.

* EC=emulsifiable concentrate; WP=wettable powder; F=flowable (see page 1). S and L mean essentially the same as EC.

SPRAY COMPATIBILITY (ABILITY TO MIX) CHART FOR FUNGICIDES AND INSECTICIDES

It may be to your advantage to control several problems with one spray by combining several chemicals. *Read the label* and follow the manufacturer's directions when making these mixtures. This compatibility chart is provided to help you in preliminary planning only. Compatibilities can vary from those indicated on this char because of change in solvents and emulsifying agents, etc. It is a good idea before making a tank mixture to mix the chemicals in a jar of water at approximately the recommended dilution rate and look for any reactions that would cause solids to form and separate out of the solution. Some mixtures may create phytotoxicity problems (plant injury), so unless a label specifies otherwise, either experiment on a few plants or avoid doing it.

	Topsin-M	Thiodan	Tedion	Sulfur	Ronilan	Plictran	Parathion*	Methoxychlor	Metasystox-R	Guthion	Diazinon	Captan	Benlate
Benlate			C	X									
Captan		1					1	1		1			
Diazinon													
Guthion				1	?							1	
Metasystox-R						C							
Methoxychlor				1								1	
Parathion												1	
Plictran									C				
Ronilan	?			?						?			
Sulfur	X				?			1		1			X
Tedion	C												C
Thiodan												1	
Topsin-M			C	X	?								

Blank=Normally compatible, however, newer compatibility charts suggest not to mix unless approved by manufacturer.
C=Caution
X=Incompatible
1=Use wettable or soluble powder forms

Note: Furadan is missing from the above chart because the compatibility data for this material are unavailable to us at this time.

EB 0848

WEED CONTROL GUIDE

Chemicals will give good control of annual weeds in both new and established strawberry plantings. However, they must be used with caution. It takes accurate application, timing, and amounts to obtain good weed control without injuring the plants or reducing their yields.

PERENNIAL WEED CONTROL

Chemicals that kill perennial weeds also damage strawberry plants. Therefore, weeds such as quackgrass, sheep sorrel, field horsetail, Canada thistle, and others that grow from old roots and stems must be killed before strawberries are planted.

To maintain an income while bringing perennial weeds under control, other crops that are resistant to perennial weedkillers can be grown. Glyphosate in corn and 2,4-D, MCPA, dicamba or glyphosate in cereal grain are a few of the ways in which weedkillers can be combined with crop production to obtain perennial weed control.

Perennial weeds also can be controlled by tillage alone. Therefore, advantages and costs of chemical applications must be weighed against costs and time spent in a clean cultivation program.

ANNUAL WEED CONTROL

Herbicides will give selective control of germinating and seedling weeds in strawberry plantings. Since several herbicides can be used safely and effectively, the choice depends upon several interrelated factors: weed species present, management practices, age of the strawberry planting, soil type, and weather conditions.

Diphenamid (Enide)

Diphenamid is effective against germinating seeds of many annual weed species. It will not kill weeds that are growing at the time of treatment. It sometimes persists in the soil for as long as five months, although under most conditions its weed-killing activity lasts only 2 to 3 months. Rainfall or overhead irrigation following application is essential for effectiveness. Under dry conditions, a shallow (1 to 2 inch) soil incorporation will improve weed control.

In new plantings, apply 2-6 weeks after transplanting. Weeds that have germinated should be removed by cultivation before application. A second application can be made 6 months later. In established plantings, application can be made either after harvest following renovation of beds or in the fall (October through December).

Rate of application[1] depends upon soil texture. Use 4 pounds active ingredient (8 pounds of 50 WP or 4.4 pounds of 90 WP Enide) per acre in coarse soils (sand, loamy sand, sandy loam); 5 pounds active ingredient (10 pounds of 50 WP or 5.6 pounds 90 WP Enide) per acre on medium soils (loam, silt loam, sandy clay loam) and 6 pounds active ingredient (12 pounds of 50 WP or 6.6 pounds 90 WP Enide) per acre on fine soils (clay, clay loam, silty clay).

Precautions:
1. Do not apply within 60 days of harvest.
2. Do not apply within 6 months of the last application.
3. Do not plant edible crops other than Irish potatoes, sweet potatoes and strawberries within 6 months after the last application of diphenamid.
4. Do not use cover crops for food or feed.
5. Do not graze livestock on treated areas.
6. Do not use in combination with fertilizers, insecticides or fungicides.
7. Follow wettable powder precautions.[2]
8. Under dry soil conditions, weed control will be poor.
9. Once weeds have become established, little or no control will be obtained.

Resistant weed species. Black nightshade, shepherdspurse, various species of mustard, smartweed, groundsel, all *established* perennial weeds.

Susceptible weed species. Annual bluegrass, barnyardgrass, witchgrass, green foxtail, yellow foxtail, wiregrass, annual ryegrass, chickweed, knotweed, lambsquarters, redroot pigweed, purslane.

Chloroxuron (Tenoran)

Chloroxuron is a soil-residual herbicide that also has foliar activity. Best results are obtained before the seedling weeds have developed the first true leaf. Rainfall or sprinkler irrigation following application is necessary to control germinating weeds. Persistence of chloroxuron activity in the soil depends on many things, but in general, spring and summer applications will last 4 to 6 weeks, fall applications 6 to 8 weeks.

In new plantings, delay application until strawberry plants are established. Annual weeds should not be past the first true-leaf stage of growth at the time of application. Chloroxuron can be applied to new plantings again in the fall (October or November) for control of fall-germinating annual weeds.

In established plantings, apply either after harvest following renovation of beds or in the fall (October or November) just after fall rains have initiated winter-annual, weed-seed germination. Chloroxuron can also be used in the spring on established plantings provided application is made 60 days before first harvest.

Rate of application[2] is 4 pounds active ingredient (8 pounds of 50 WP Tenoran) per acre. At this rate of application, do not add spreader-sticker to spray mix. However, during the dormant season, the addition of a spreader-sticker makes it possible to kill fully grown chickweed with no injury to the strawberries.

Precautions:
1. Do not apply more than two times during any one year.
2. Do not apply within 60 days of harvest.
3. Use other herbicides when grasses are the major weed problem; chloroxuron is a poor grass killer.
4. Will not control established perennial weeds.
5. Do not apply chloroxuron when air temperature is 75°F or higher to avoid excessive burn injury on strawberry foliage.

6. Do not apply to strawberry plants under stress.
7. Follow wettable powder precautions.[2]
8. Thoroughly rework soil before planting succeeding crops.

Resistant weed species. Annual grasses, prostrate knotweed, pineappleweed, all *established* perennial weeds.

Susceptible weed species. Black nightshade, chickweed, shepherdspurse, lambsquarters, redroot pigweed, smartweed, spurry, various species of mustard.

Napropamide (Devrinol)

Napropamide can be used in Washington for weed control in new and established plantings of strawberries. It has a good margin of safety and controls many different species of annual weeds. Control of germinating weed seed has lasted as long as 8 months and sometimes longer. At least one inch of rainfall or overhead irrigation following application is essential for effectiveness otherwise the material is degraded by sunlight. The surface 2 to 4 inches of soil must be wet within one day after application during the summer and within 10 days during late fall in order to obtain good control of germinating weed seed. Since napropamide has little or no effect on emerged weeds, it should be applied before they emerge.

In new plantings, apply napropamide soon after transplanting but before weed-seed germination. In established plantings, application can be made during October through March to weed-free soil.

Rate of application[1] is 4 pounds active ingredient (8 pounds of 50 W Devrinol) per acre.

Precautions:
1. At least 1/2 inch of rainfall or irrigation within a week after application is necessary for weed control.
2. Napropamide will not control established weeds.
3. Do not apply more than once per season.
4. When applied to new plantings, the setting of runners is sometimes inhibited.
5. Follow wettable powder precautions.[2]
6. Do not use on soils with over 10% organic matter.
7. Weed control will be reduced when soil is heavily covered with leaves or trash.
8. Do not plant alfalfa, small grains, corn, lettuce, or beets for 12 months after application.
9. Use an alternate herbicide in the last harvest year to avoid residue injury on the crop following strawberries.
10. Do not apply from bloom to harvest.
11. Application of the material should be delayed until the desired number of daughter plants have become established.

Resistant weed species. Shepherdspurse, species of mustard, henbit, minerslettuce, black nightshade, smartweed, all *established* perennial weeds.

Susceptible weed species. Annual bluegrass, barnyardgrass, wild oats, chickweed, common fiddleneck, knotweed, little mallow, purslane, common sowthistle, filaree, groundsel, lambsquarters, pineapple-weed, prickley lettuce, redroot pigweed.

Simazine (Princep)[□]

Simazine should only be used on established plantings. It may be applied in irrigated fields after post-harvest renovation and again during October through November. In non-irrigated fields apply it once during September through November as determined by expected weed seed germination and rainfall. Weeds that have germinated should be hoed out before application.

Rate of application[1] is 1 pound active ingredient (1.25 pounds of 80 WP Princep) per acre.

Precautions:
1. Rainfall or irrigation soon after application is necessary for good weed control.
2. Do not apply during late winter or in the spring.
3. Do not apply to very loose, sandy, or coarse soil.
4. Limit irrigation to 1/2 inch after postharvest renovation application.
5. Adequate control of weeds in northwestern Washington requires two applications per year.
6. Follow wettable powder precautions.[2]

Resistant weed species. All established perennial weeds, triazine resistant lambsquarters, and redroot pigweed.

Susceptible weed species. Annual bluegrass, chickweed, groundsel, lambsquarters, nightshade, redroot pigweed, mustard spp, and smartweed.

Simazine plus Napropamide

This combination increases the number of weed species controlled and greatly increases the length of effective control. Apply during October through November. Do not apply in the spring. Follow all precautions as given previously for simazine and napropamide alone.

Rate of application[1] is 1 pound active ingredient (1.25 pounds of Princep 80 WP) plus 4 pounds active ingredient (8 pounds of Devrinol 50 W) per acre.

Terbacil (Sinbar)

Based on field testing in western Washington over the last three years, as well as on label recommendations, the following use directions should prove effective and selective in western Washington strawberry fields. Apply immediately after postharvest renovation or in the dormant season (late fall through late winter). Rate of application is .4 to 1 pound active ingredient (.5 to 1.25 pounds of 80W Sinbar) per acre.

□A special local needs registration has been granted for this use in Washington under Section 24(c), FIFRA.

Restrictions/Precautions:

1. Use only on plants established in the field for at least 6 months.
2. Use the lower rate on course-textured soils (sands, sandy loams, loamy sands, etc.); higher rate on fine-textured soils (clays, silts, silt loams, etc.). Do not use on soils with less than 2% organic matter.
3. When application is made after postharvest renovation, complete removal of old leaves, stems, etc., is essential. Apply Sinbar before new growth begins.
4. When application is made during the dormant season (usually mid-November to early February), treat before weeds are 2 inches tall or 2 inches across.
5. Strawberries growing in low-lying or poorly drained areas will be severely injured or killed by Sinbar treatment.
6. Do not tank-mix Sinbar with other herbicides or liquid fertilizers and pesticides.
7. Sinbar may reduce runner production or plant stand.
8. Do not apply to strawberries under stress due to drought, insect or plant disease infestations, poor drainage, etc.
9. Certain varieties (Totem) may not be tolerant to Sinbar treatment.
10. Do not plant any crop within 1 year after last application of Sinbar.

Resistant Weed Species. All established perennial weeds.

Susceptible Weed Species. All annual weeds.

Other Herbicides

Herbicides listed below are currently registered for use in strawberries; however, they have been judged unsuitable in western Washington for one or more of the following reasons: (1) a high probability of strawberry injury, (2) ineffectiveness on the weed species commonly infesting strawberries, (3) inappropriate under the usual environmental conditions and/or managerial practices common to western Washington agriculture and, (4) availability of better and less costly alternative herbicides.

DCPA (Dacthal)
Dinoseb (Premerge 3)
2,4-D amine (several trade names)

Methods of Application

Uniform application is absolutely necessary if herbicides are to provide the desired results.

Treatment rates are low. For example, only 1.25 pounds of 80 WP Princep are needed per acre. Such a small amount of material spreads very thinly over an acre. Variations in the spray pattern, overlap, speed of the rig, worn nozzle tips, etc., will change the application rate sufficiently to damage the crop or reduce the weed control.

To get uniform application, be sure that your sprayer:

1. Can apply material at low pressures, 30 to 40 pounds per square inch.
2. Can apply 40 to 60 gallons of spray per acre.
3. Has nozzles spaced evenly, 12 to 18 inches apart, along a boom that can be adjusted for height.
4. Can move at a constant ground speed between 2 and 4 miles per hour.
5. Will cover the entire area with a broadcast application.
6. Has nozzle tips that deliver the rated volume of spray (test the output of the individual tip to determine its accuracy).

[1] All rates of application are given in pounds active ingredient per acre; also rates of application are based on complete (overall) coverage. Reduce amounts used per acre proportionately for band or strip treatment. Rate of application per square foot treated should remain the same.

[2] Wettable powder formulation precautions should be observed—wettable powders go into suspension, not solution. Therefore, constant agitation is required to keep the powder in suspension for uniform spraying. Mechanical agitation is preferred over hydraulic agitation. Line and nozzle strainers should be at least 50 mesh to permit free passage of the wettable powder spray mixture through the spraying system. Since wettable powders are abrasive, sprayers should be recalibrated frequently.

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APPROXIMATE METRIC WEIGHTS AND MEASURES

COMMON EQUIVALENTS

Metric	U.S.	
Millimeter	0.039	inches
Centimeter (10 mm)	0.39	inches
Meter (100 cm)	39.4	inches
Kilometer (1,000 m)	0.62	miles
Square Centimeter	0.155	square inches
Square Meter	1.2	square yards
Hectare (10,000 sq m)	2.47	acres
Square Kilometer (100 ha)	247	acres
Gram	0.035	ounces
Kilogram (1,000 g)	2.2	pounds
Ton (metric) (1,000 kg)	1.1	tons (US)
Milliliter	0.034	fluid ounce
Liter (1,000 ml)	1.056	quarts
Cubic Meter (1,000 l)	264.17	gallons (US)

U.S.	Metric	
Inch	2.54	centimeters
Foot (12 in)	30.5	centimeters
Yard (3 ft.)	0.91	meters
Mile (5,280 ft.)	1.6	kilometers
Square Inch	6.5	square centimeters
Square Foot (144 sq. in.)	930	square centimeters
Square Yard (9 sq. ft.)	0.84	square meters
Acre—43,560 sq. ft.	0.405	hectares
Square Mile—640 acres	259	hectares
Ounce	28.3	grams
Pound—16 oz.	0.454	kilograms
Ton (US)—2,000 lb.	0.907	tons (metric)
Tablespoon—3 teaspoons	14.79	milliliters
Fluid Ounce—2 tablespoons	29.6	milliliters
Cup—8 fl. oz.	0.237	liters
Pint—2 cups	0.473	liters
Quart—4 cups	0.946	liters
Gallon (US)—4 qts.	3.8	liters
Cubic Foot	28.3	liters

PROPORTIONS

Metric	U.S.	
100 g/ha	1.4	oz./acre
1 kg/ha	0.9	lb./acre
1 ton (metric)/ha	0.446	tons (US)/acre
1 l/ha	0.4	qt./acre
1 kg/1000 l	1	lb./100 gals.
1 g/1000 kg	1	ppm
1 km/hr	0.6	mph

U.S.	Metric	
1 oz./acre	70	g/ha
1 lb./acre	1.12	kg/ha
1 ton (US)/acre	2.24	tons (metric)/ha
1 fl.oz./acre	73	ml/ha
1 gal./acre	9.39	l/ha
1 lb./100 gals	1	kg/1000 l
1 ppm	1	g/1000 kg
1 mph	1.6	km/hr

TEMPERATURES

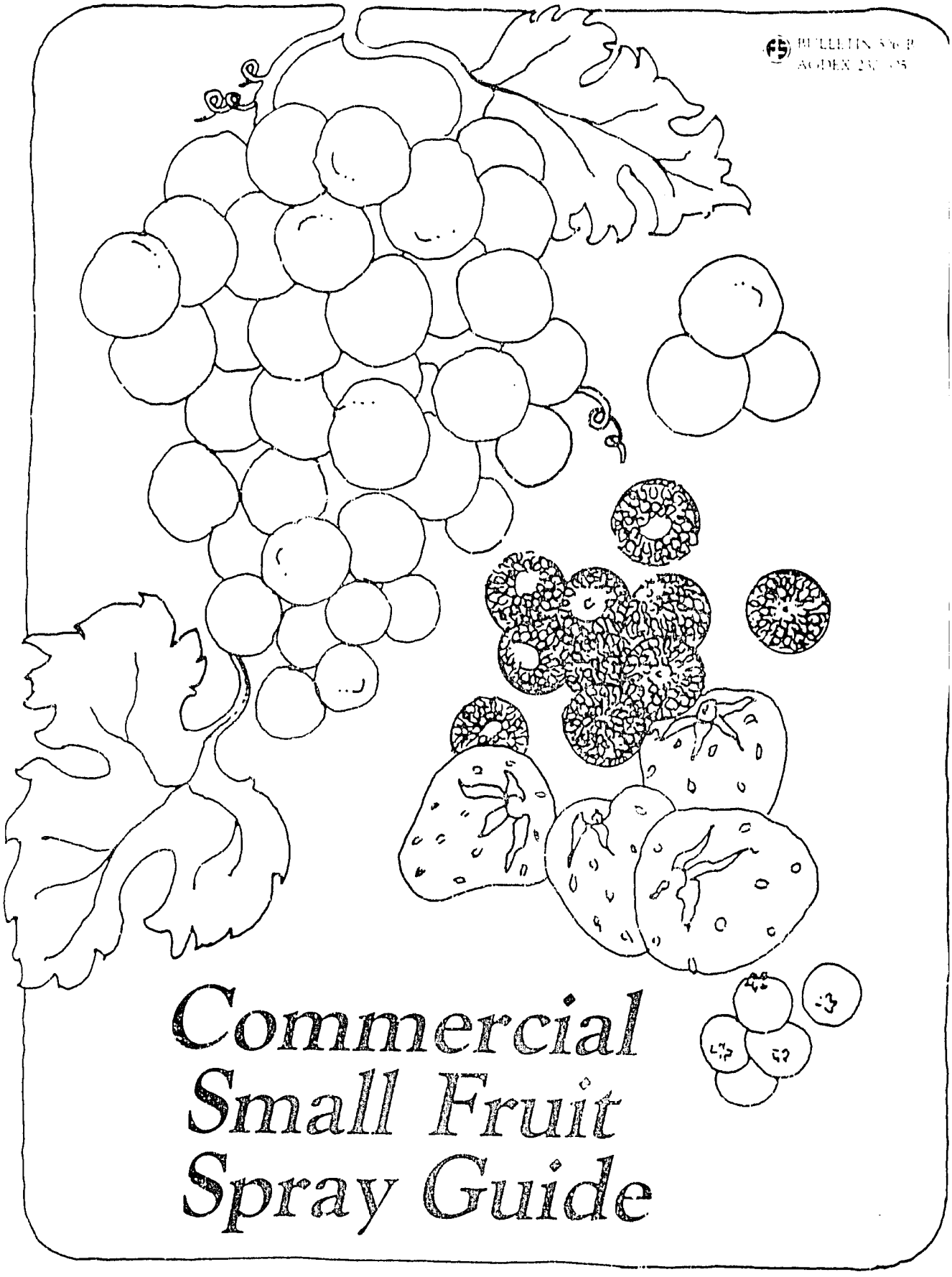
Celsius (Centigrade)	Fahrenheit
-30	-22
-20	-4
-10	14
0	32
10	50
20	68
30	86
40	104

Fahrenheit	Celsius (Centigrade)
0	-18
10	-12
20	-7
30	-1
40	4
50	10
60	16
70	21
80	27
90	32

To convert: Celsius to Fahrenheit — multiply by 9/5 (1.8) and add 32.
Fahrenheit to Celsius — subtract 32 and multiply by 5/9 (0.56).

ABBREVIATIONS

mm — millimeter, cm — centimeter, m — meter, km — kilometer, ha — hectare, mg — milligram, g — gram, kg — kilogram, l — liter
ml — milliliter



Commercial Small Fruit Spray Guide

OSU Ohio Cooperative Extension Service
The Ohio State University

Effectiveness of Pesticides Used for the Control of Strawberry Insects and Mites

Chemical	Aphids	Clipper	Cyclamen mite	Leathoppers	Leafrollers	Root Weevils	Rootworms	Slugs	Sap Beetle	Spider Mites	Spittlebug	Tarnished Plant Bug	White Grubs	Pre-harvest Interval (Days)
Diazinon	+++	-	-	++	++	+	-	-	++	-	++	+	++	5
Dibrom (Naled)	-	-	-	-	-	-	-	-	++	-	-	-	-	1
Guthion	-	++	-	-	+++	-	-	-	++	-	++	+	-	5
Kelthane	-	-	++	-	-	-	-	-	-	+++	-	-	-	2
Lindane	-	++		-	-	-	-	-	-	-	++	-	+++	b
Lorsban	-	+++	-	-	-	-	-	-	-	-	-	-	-	b
Malathion	-	-	-	-	-	-	-	-	+	-	-	++	-	3
Metaldehyde	-	-	-	-	-	-	-	++	-	-	-	-	-	a
Methomyl		-	-	-	-	-	-	-	-	-	-	++	-	3a
Methoxychlor	-	++	-	-	-	-	+	-	-	-	++	-	-	14
Parathion	-	++	-	++	++	-	-	-	-	-	-	++	-	14
Plictran	-	-	-	-	-	-	-	-	-	+++	-	-	-	1
Sevin	-	-	-	-	+	-	-	-	-	-	++	-	-	1
Systox	+++	-	-	+++	-	-	-	-	-	-	-	-	-	21
Thiodan	+++	-	+++	-	-	-	-	-	-	-	+++	+++	-	4a
Zendex	-	-	-	-	-	-	-	-	-	+++	-	-	-	1

++ =Highley effective; ++ = moderately effective; + = slightly effective; - = not sufficient data.
a = See label restrictions.
b = Do not apply after fruit begins to form.

Bearing Plants

Early Spring
When buds emerge

Insects and Diseases	Insecticides and Fungicides	Dilute Rate/100 Gals	Rate/Acre
"Clipper" strawberry weevil	If you have had previous problems with the "Clipper" (strawberry weevil), this would be the time to make first insecticide application. A second spray should be applied just before bloom. See "Specific Strawberry Insects and Their Control."		
Botrytis blossom blight blight leaf spots	Captan (50% WP)	3 lbs	6 lbs
	or		
	Thiram (65% WP)	2.5 lbs	5 lbs

Standard dilute rate for strawberry is 200 gallons/acre.

Pre-Bloom
When very first blooms open

Tarnished plant bug (TPB)	If you have had previous problems with TPB, apply insecticides just before bloom or as first blooms appear. See "Specific Strawberry Insects and Their Control."		
Blossom and fruit rots leaf spots	Topsin M (70% WP)	.5 lb	1 lb
	or		
	Benlate (50% WP)	.5 lb	1 lb
	or		
	Ronilan (50% WP)	.5 to 1 lb	1 to 2 lb
	plus		
	Captan (50% WP)	2 lbs	4 lbs
	or		
	Captan (50% WP) used alone	3 lbs	6 lbs
	or		
	Thiram (65% WP) used alone	2.5 lbs	5 lbs

Strawberries

Full Bloom

Insects and Diseases	Insecticides and Fungicides	Dilute Rate/100 Gals	Rate/Acre
Blossom and fruit rots-Leaf spots	Same materials and rates as Pre-Bloom. (DO NOT APPLY INSECTICIDES DURING BLOOM)		

Note
*Fungicide sprays during bloom are extremely important for control of gray mold fruit rot and blossom blight

First Cover

5 to 7 days after pre-bloom

Blossom and fruit rots Leaf spots	Topsin M (70% WP)	.5 lb	1 lb
	or		
	*Ronilan (50% WP)	.5 to 1 lb	1 to 2 lbs
	or		
	Benlate (50% WP)	.25 lb	.5 lb
	plus		
	Captan (50% WP)	2 lbs	4 lbs
	or		
	Thiram (65% WP)	2 lbs	4 lbs
	or		
	Folpet (50% WP)	2 lbs	4 lbs
	or		
When Topsin-M, Ronilan* or Benlate are not used in the program, use	Captan (50% WP)	3 lbs	6 lbs
	or		
	Thiram (65% WP)	2.5 lbs	5 lbs
Spittlebugs	Thiodan (50% WP)	1 lb	2 lbs
	or		
Tarnished plant bugs	Guthion (50% WP)	.5 lb	1 lb
	or		
Leafrollers Aphids	Malathion (25% WP)	2.5 lbs	5 lbs
	or		
	*Sevin XLR Pluss (4 lbs. carbary/per gallon)	1 gt.	2 qts.

Notes:
* Ronilan—the highest rate of ronilan should be used when disease pressure is high and foliage is dense. Read the label for more information.
In order to prevent or delay the development of Botrytis (the gray mold fungus) strains with resistance to fungicide, we recommend that Ronilan, Topsin-M and Benlate never be used alone in the spray program. In addition, Ronilan, Topsin-M and Benlate have no effect on the fungus that causes leather rot. The use of captain, folpet or thiram in combination with Ronilan, Topsin-M or Benlate should aid in controlling leather rot.

Second Cover

7 days after first cover

Insects and Diseases	Insecticides and Fungicides	Dilute Rate/100 Gals	Rate/Acre
Fruit rots Leaf spots	Topsin M (70% WP)	.5 lb	1 lb
	or		
	Ronilan (50% WP)	.5 to 1 lb	1 to 2 lbs
	or		
	Benlate (50% WP)	.25 lb	.5 lb
	plus		
	Captan (50% WP)	2 lbs	4 lbs
	or		
	Thiram (65% WP)	2 lbs	4 lbs
	or		
	Folpet (50% WP)	2 lbs	4 lbs
	or		
When Topsin-M, Ronilan or Benlate are not used in program, use	Captan (50% WP)	3 lbs	6 lbs
	or		
	Thiram (65% WP)	2.5 lbs	5 lbs

Third and Late Covers

At 7-day intervals after second cover until harvest

Insects and Diseases	Insecticides and Fungicides	Dilute Rate/100 Gals	Rate/Acre
Fruit rots Leaf spots	Topsin M (70% WP)	.5 lb	1 lb
	or		
	Ronilan (50% WP)	.5 to 1 lb	1 to 2 lbs
	or		
	Benlate (50% WP)	.25 lb	.5 lb
	plus		
	Captan (50% WP)	2 lbs	4 lbs
	or		
	Folpet (50% WP)	2 lbs	4 lbs
	or		
When Topsin-M, Ronilan or Benlate are not used in program, use	Captan (50% WP)	3 lbs	6 lbs
	or		
	Thiram (65% WP)	2 lbs	4 lbs

Notes:

Fungicide or insecticide dusts or combinations of such may be used instead of spray. If they are used, their active ingredient content must be known and their application rate adjusted so as to apply the same quantities of active ingredients per acre as would be applied in the sprays recommended above. For example, a 40 lb per acre application of 7.5 percent captan dust would be equivalent to a 300 gallon per acre spray of 50% captan at 2 lbs per 100 gallons.

Standard dilute rate for strawberries is 200 gallons per acre. If less than 200 gallons is used, increase concentration of spray to apply equivalent amounts of pesticide per acre.

Unnoticed blossom rot may materially reduce yields even when fruit rot is not evident at harvest.

The wetter the season, the more necessary it will be to apply the second cover and later sprays.

Thiram may be used only to within three days of first picking. Captan, Folpet, Benlate and Ronilan have no time restriction on strawberry.

When spraying during bloom, bees may be killed. See section on "Toxicity of Various Pesticides to Honeybees."

Post-Harvest and New Plantings

Leaf spots	Benlate (50% WP)	.25 lb	.5 lb
	plus		
	Captan (50% WP)	2 lbs	4 lbs
	or		
	Captan (50% WP)	3 lbs	6 lbs
	or		
	Thiram (65% WP)	2.5 lbs	5 lbs

Notes:

This treatment is used for new plantings and in bearing plantings after renovation. Especially during wet seasons, the incidence of leaf diseases can increase, resulting in weakened plants and increased primary inoculum for the next season. During wet seasons, regular fungicide treatments may be needed to check these diseases. Repeat the above spray every 7 to 10 days until weather conditions improve.

STRAWBERRIES

"Registered" Disease-Free Planting Stock Essential

The use of disease-free strawberry plants for the establishment of new plantings is of the utmost importance to the success of any strawberry venture. The use of planting stock containing only a few plants infected with red stele root rot, Verticillium wilt or root knot nematodes can result in disaster and will contaminate the site for future use. Virus diseases, which were almost universally present in planting stock a few years ago, definitely restrict plant stands and yields of strawberries. Substantially virus-free plants of most varieties are now commercially available. This grade of stock is designated "Registered." Use of registered plants is the best possible insurance against losses from the above-named diseases.

Strawberries

Specific Strawberry Diseases and Their Control

Pest	Description of Injury or Pest	Control
Red stele root rot	Plants first appear stunted and dull in color, then wilt and eventually die, usually just before or during harvest. Roots of plants decay and show reddish or brown cores. Roots become devoid of fibrous, lateral rootlets, giving them a rat-tailed appearance.	Use disease-free plants on well-drained, porous soil that is uncontaminated by the red stele fungus. Causal fungus remains in soil for many years. Rotate crops with at least four years between strawberries (more if possible). Avoid wet, tight soils. Use red stele resistant varieties when they are adapted to your area. Red stele resistant varieties suitable for Ohio are Midway, Red Chief, Sparkle, Surecrop and Guardian. These varieties are especially recommended in situations where red stele root rot has been a problem.
Powdery mildew	Edges of leaves roll upward and have a thin white powdery mold growth on the lower surface.	Benlate is labeled for control of powdery mildew on strawberries. Where Benlate is used, mildew should not be a problem.
Verticillium wilt	Wilting and death of scattered or individual plants, usually in first-year plantings during summer months. Internal browning of crown tissue usually evident. Earlidawn variety is very susceptible.	Plant disease-free stock from approved sources. Avoid soil that may be heavily infested with the Verticillium fungus. Especially avoid planting strawberries following crops of solanaceous plants such as potatoes, tomatoes and eggplant.
Virus diseases	Reduced runner formation and decreased vigor and yield. No conspicuous symptoms on most commercial varieties. Aphids can spread viruses.	Plant only "Registered" virus-free plants. When such stock is used and the planting will be used for plant production, follow aphid control program to reduce rapid spread of virus.

Specific Strawberry Insects and their Control

Rootworm (strawberry leaf beetle)	Small beetles eat numerous holes in the leaves. Adult beetles feed at night. Larvae feed on roots.	This insect is seldom a problem. However, if beetles become very abundant, apply methoxychlor. Beetles are active at night.
Strawberry leafroller	Leaflets folded and webbed together with a small green larva feeding within.	If an infestation develops in a new planting, or if reinfestation occurs on bearing planting, spray with Guthion (½ lb of 50% WP per 100 gals water). Do not use Guthion within 5 days of harvest. Or use Sevin SLR PLUS at the rate of 1½ quarts per acre. The interval between last spray and harvest is 1 day.
Spittlebugs	White, frothy masses ½-inch or less in diameter covering small, greenish-yellow insects on stems and leaves.	In areas where spittlebug infestations have been severe, include 1 lb Thiodan (50% WP) per 100 gallons of water in spray No. 2 of the scheduled spray program or when spittle masses are first seen. Do not reapply within 15 days or more than twice within a 35-day period when fruit is present. Do not apply within 4 days of picking. Guthion (½ lb of 50% WP) may be used. Do not use Guthion within 5 days of harvest. Or use Sevin SLR PLUS at the rate of 1½ quarts per acre. The interval between last spray and harvest is 1 day.

Specific Strawberry Diseases and Their Control

Pest	Description of Injury or Pest	Control
Tarnished plant bug (TPB)	Brassy-brown bugs about ¼-inch long feed on buds before bloom and deform fruits. The most characteristic feature of TPB-injured fruit is the apical seediness of the berries. These berries are small and are called "button berries."	Just before bloom or when insects appear, spray plants, mulch and surrounding area. Use Guthion (1 lb 50% WP per acre), Thiodan (2 lbs 50% WP per acre), Malathion (4 lbs 25% WP per acre); or methomyl (Nudrin or Lannate). Do not treat when bees are active. Read label.
White grubs	Large, fleshy, white grubs 1 to 2 inches long attack the roots of young plants.	See "Strawberries Following Sod." Nothing can be done to control grubs after the plants have been set out or in an established planting without destroying the plants.
Sap beetle	Brown beetles about ¼-inch long, oval in shape, lie quite flat. They feed on ripe berries and continually migrate into strawberry plants all summer.	Keep over-ripe and injured berries from accumulating.
Strawberry aphids	Small greenish to yellowish, soft-bodied insects feed on new shoots and undersides of leaves.	To prevent virus, spray with Systox 2 (25% E) 1½ pints per acre in sufficient water for complete coverage about September 1 and again in 3 week, if aphids are still present. Apply Systox again in spring before bloom. Do not apply Systox within 21 days of harvest on any strawberry plants. Dust with 7.5% malathion every 14 days to control aphids through the growing season or spray at same intervals with malathion (25% WP) 2½ lbs per 100 gallons of water. Do not apply malathion within 3 days of harvest. Thiodan (50% WP) 1 lb (see restrictions under spittlebugs).
Mites Cyclamen mite Two-spotted spider mite	Leaves distorted and discolored. Fruits may be stunted. Two-spotted spider mite may form silken webs on lower surface of leaves. Cyclamen mite causes edges of leaves to be distorted and disfigured, and heavily infested plants are stunted.	For one or both species, spray with Kelthane (2 lbs 35% WP) or (2 qts 18.5% EC) per 100 gallons of water. May be used until 2 days prior to harvest. Thiodan as suggested for spittlebugs will control cyclamen mites. Do not re-apply within 15 days or more than twice within a 35-day period when fruit is present. Do not apply within 4 days of picking. Both Plictran and Vendex are labeled for two-spotted spider mite. Plictran 50W can be used at rate of 1 lb per 200 gallons of water per acre. Vendex 4L at the rate of 2 pts. and Vendex 50WP at the rate of 2 pounds per 200 gallons of water. Both Plictran and Vendex can be used up to one day of harvest.
Leafhopper	Leaves become stunted and curled. Young plants suffer most serious injury.	Apply malathion (25% WP) at 2½ lbs 100 gallons of water or methoxychlor (50% WP) at 2 lbs/100 gallons of water. Harvest restriction: malathion, 3 days, methoxychlor, 14 days.

Strawberries

Specific Strawberry Diseases and Their Control

Pest	Description of Injury or Pest	Control
"Clipper" or strawberry weevil	Cuts buds and partly severs stems. Watch for small holes in the petals when first blooms open.	Timing is very important. Treat early when growth begins in the spring. Lorsban, Guthion and Parathion are all labeled. Lorsban has given excellent results.
Slugs	Slugs make moderately deep holes in ripening berries. These holes may be recognized because of a slimy trail left on the surface of the fruit.	The only product labeled for strawberries is Bug-Geta Snail and Slug Pellets by Ortho. These pellets contain metaldehyde. Follow directions on product label.
Rootweevils	Black weevils appear during late June and feed on foliage at night. Larvae enter the soil and feed on roots.	Post-harvest plow under old beds as soon as possible to prevent root-weevil spread to new beds

Strawberries Following Sod

White Grubs

The major problem of planting strawberries following sod is the likelihood of the soil being infested with white grubs. Several species of grubs will attack the roots of new strawberry plants.

Plan planting sites a year in advance. Many times this can eliminate the need for insecticide applications for grubs. If your next site is following sod, plant to an alternate cultivated crop or cover crop before planting to strawberries.

Ortho Isotox Lindane Wettable 25, a Chevron product, is the only material labeled for grub control at this time. Directions for use: Pre-plant Treatment—1 to 2 pounds per acre. Apply as spray or dust directly on soil. Disc as soon as practical to give thorough distribution in upper 4 to 6 inches of soil. Can be mixed with acid or neutral fertilizers and applied with fertilizer drill. Lindane is presently under RPAR and could be pulled off the market at any time.

Control First Year and Renovated Plantings

No general spray program is recommended for first year strawberry plantings or for after harvest in plantings that are kept for second year crops. Insect pests that can be controlled by spraying vary greatly in severity from year to year and in different localities and may not always require spray treatment. For treatment of insect pests in non-bearing plantings, the grower is referred to the section "Specific Strawberry Insects and Their Control." Treatment for individual pests should be made when the need is indicated.

Herbicides for Strawberries

Suggested Schedule

I. Before Planting:
Weed control prior to planting is important. Within label limitations use herbicides with cultivated crops such as corn. Treat fields at least one year ahead of planting. Fumigation with methyl-bromide will control many weeds. Read all labels before using these methods.

II. New Plantings:

Preplant soil incorporate or immediately (3 days) after planting	Dactal 75% 8-12 lbs/A
After planting (3 days)	Devrinol 50% (before May 15) 4-6 lbs/A
After 3 new leaves	Tenoran 50% 6-8 lbs/A plus Enide 50%* 8 lbs/A sandy soil, 10 lbs/A heavy soil *or* Devrinol (before May 15) 4 to 6 lbs/A
September	Dacthal 75% 12 lbs/A *or* Devrinol 50% 4-6 lbs/A *or* Enide 50% 8 lbs/A *plus* Tenoran 10 lbs/A
November to Mid-December	Tenoran 50% 6-8 lbs/A *plus* Enide 50% 8 lbs/A sandy, 10 lbs/A heavy *or* Sinbar 80% WP .5 to .75 lbs/A *or* Devrinol 50% WP 4-6 lbs/A *or* Sinbar 80% A .75 lbs/A *plus* Enide 50% 8 lbs/A *or* Sinbar 80% .75 lbs/A *plus* Devrinol 50% 6 lbs/A
III. Fruiting Field: Before blossoms open	Dacthal 75% WP 12 lbs/A or Devrinol 50% WP 4-6 lbs/A *or* Tenoran 50% 6-8 lbs/A (60 days before harvest)
After harvest: 1. Before renovation Apply and wait 8 to 10 days	2-4D (Amine) 1 to 1.5 qts/A
2. At renovation 8 to 10 days after 2-4D	Sinbar 80% WP .5 to .75 lbs/A *or* **Devrinol 50% WP 4-6 lbs/A

3. After renovation (if leaves are present)	Enide 50%* 10 lbs/A *plus* Tenoran 50% 6-8 lbs/A

*Enide 90W—apply 4.4 to 5.5 lbs/A.
**Devrinol can be used in high density systems where runners are not required.

September	Dacthal 75% WP 12 lbs/A *or* Devrinol 50% WP 4-6 lbs/A *or* Enide 50% 8 lbs/A *plus* Tenoran 50% 10 lbs/A
Mid-November to Mid-December	Enide 50% 10 lbs/A *plus* Tenoran 50% 6 lbs/A *or* Sinbar 80% WP .5 to .75 lb/A *or* Devrinol 50% WP 4-6 lbs/A

Notes:

Dacthal

Incorporate into soil before planting.
Apply before rain or incorporate by irrigation.
Apply before weeds emerge.

Tenoran

Apply before weeds emerge.
Will kill certain small seedlings.
Weak on grasses.
Has done well in combination with Devrinol 50% (4 to 6 lbs/acre).
May be used at other times than those listed.
Do not apply when temperature is above 90°F.
Do not apply within 60 days of harvest.
Do not apply more than twice per season.

Enide

Apply to weed-free soil.
Will control volunteer grains.
Allow six-month interval between applications.
Shallow incorporate or incorporate with water.
Do not apply to Raritan or Darrow until established.
Do not apply within 60 days of harvest.
Do not apply near runner root formation.

2-4D

Apply at renovation for control of broadleaf weeds.
Do not apply between mid-July and dormancy—affects flower bud formation.

Sinbar

Apply to dormant plants only; after a hard frost, when leaves are gray, or at renovation but within 48 hours after mowing tops.
Use only one application per season.
Guardian and Red Chief are sensitive.
May replant one year after last application.
At renovation apply within 48 hours after leaves are mowed off.
Do not overlap or over apply.
Do not apply in low, wet areas.

Devrinol 50% W or 2 E

Apply after daughter plant is established or low rate before May 15 or planting year.
Incorporate with ½ inch water if no rainfall in three days after application.

Excellent grass, grain, purslane and lambsquarter control.
Apply only once per season.
Apply fall to spring for volunteer grain and grass control through spring harvest.
Can be used in high density systems where runners are not required.
Do not apply pre-plant.
Do not apply at renovation.
Do not apply near bloom.
Do not apply near runner root formation.

BIRD CONTROL

By Thomas M. Stockdale
Extension Wildlife Specialist
The Ohio State University

Ripening native fruits and berries are included among the foods eaten by many kinds of birds. Cultivated fruits, especially cherries, grapes and berries, are equally if not more attractive to these same birds. Damage and loss of ripening fruits and berries are the principal problems caused by birds. Less common is the problem caused by large numbers of birds establishing a night roost in fruit trees.

Problem Species

Starlings and robins are the species of birds most often causing problems in Ohio fruit and berry production areas. Blue jays, warblers, blackbirds and sparrows may also cause problems. All of these with the exception of the starling and house sparrow are protected as songbirds by state and federal laws. As a result, methods that scare, repel or mechanically exclude birds from the ripening fruit are the most satisfactory controls recommended. Before employing lethal control measures on unprotected species, all species feeding in the area should be identified and any lethal control method employed should create no hazard to non-target organisms.

Control Methods and Materials

Wild birds seldom venture far from natural cover to feed. Therefore, when selecting new sites for the establishment of fruit production units, stay well away from wooded areas, brushy fencerows, ditch and stream banks, and similar areas. Good grass and weed control within and adjacent to the production unit will also reduce its attractiveness to birds.

The use of sound is a common method of scaring or repelling birds from fruit production areas. Several devices are commercially available that produce such sounds. Exploders, devices that ignite a gas (usually LP gas) and create a loud boom, can be employed. Each exploder, when properly employed, will protect from one to five acres. Devices which emit electronically produced sounds are also widely used to scare birds today. The most common of these is the "Av-Alarm" system. Models are available for operation with either 12 or 110 volt power. These devices produce a variety of sounds that will scare birds as well as some mammals from the protected area. Finally, two-shot shotgun shells and fireworks may be used independently or to reinforce other audio-scaring devices.

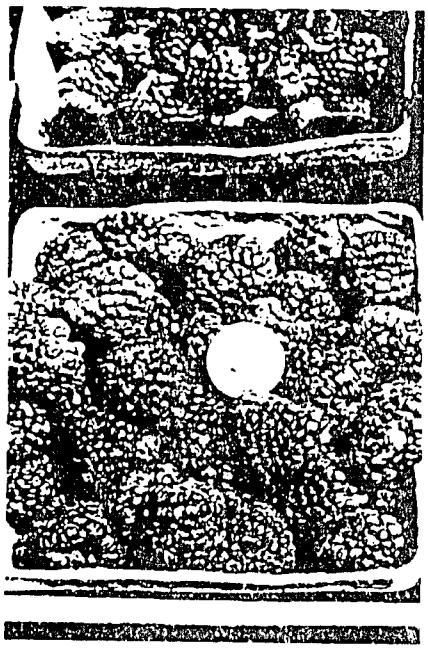
The key to the effectiveness of any scaring method is its proper use. **Scaring device operation should commence before birds are observed feeding in the production area.** Such use will prevent the development of a regular feeding pattern by the pest birds. Birds that have developed such a pattern are much more difficult to scare away. Timing devices that turn the device off and on at pre-set intervals are available for most audio-scaring devices.

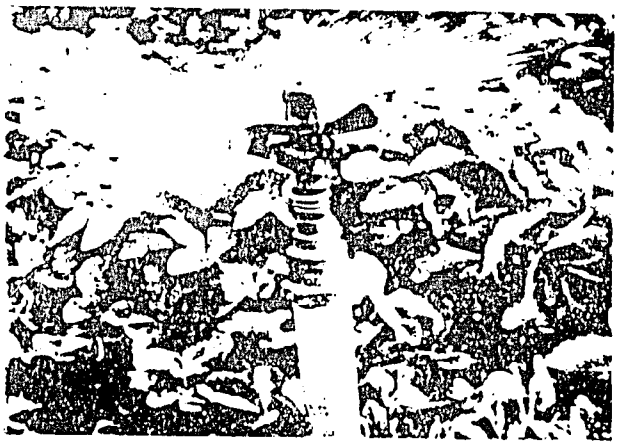
Mesurol—Chemical Control

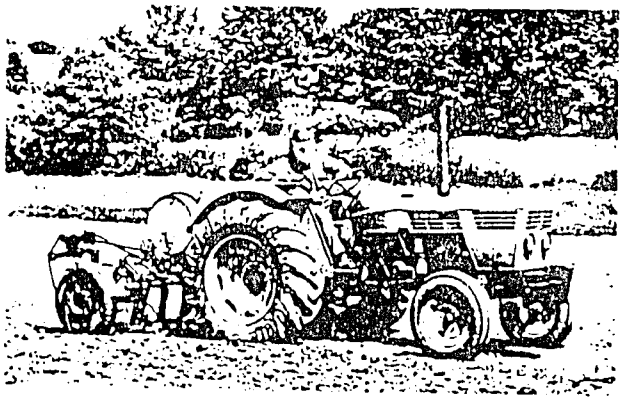
One chemical repellent is now labeled for bird control in blueberries. This is Mesurol, a material applied as a spray that discourages birds from feeding on the ripening fruit. Experimental continues on this product and labeling for other fruits is anticipated. Apply 2 pounds per acre. Mesurol may be applied up to seven days of harvest on blueberries.

The mechanical exclusion of birds is another method for protecting fruit. Several companies now manufacture plastic netting that can be draped or suspended on wires over plants. It has proved especially suitable for use on wine grapes and blueberries.

1987 Cornell Recommendations for Small-Fruit Production







New York State College of Agriculture and Life Sciences, Cornell University, Ithaca,
and New York State Agricultural Experiment Station, Geneva, Cooperating

Strawberries

June bearers
Expected yield: 5,000-12,000 lb/A
Year of fruiting: Second
Fruiting season: June-July
Life of planting: 5 years or more
Hardiness: −35° F
Spacing (matted row): 18" x 48"
(ribbon row): 3" x 36"-6" x 48"
Density: 7,260-58,080
Optimal pH: 5.5-6.5 (6.2)

Double-cropping everbearers
Expected yield: 2,000 lb/A
Year of fruiting: Second
Fruiting season: June, September
Life of planting: 5 years or more
Hardiness: −40° F
Spacing: 18" x 48"
Density: 7,260
Optimal pH: 5.5-6.5 (6.2)

Day-neutral everbearers
Expected yield:
Year 1: 3,000-8,000 lb/A
Year 2: 6,000-14,000 lb/A
Year of fruiting: First
Fruiting season: June-October
Life of planting: 3 years
Hardiness: −35° F
Spacing (matted row): 18" x 48"
(ribbon row): 3" x 36"-6" x 48"
Density: 7,260-58,080
Optimal pH: 5.5-6.5 (6.2)

Preplant Soil Modification

Lime may be required to raise soil pH to 6.2. To calculate the amount of lime required in a particular site, obtain the pH and CEC value from the soil test results. Using table 25, find the number at the intersection of the appropriate exchange acidity (CEC) column and pH row. This number is the tons of 100% ENV lime needed per acre. For example, 5.7 tons are required if the pH is 5.0 and the CEC is 14.

The number obtained from table 25 assumes the lime is 100% effective at neutralizing the acid in the soil. No lime is 100% effective; therefore, one must divide by the lime score to find the actual amount to apply. Continuing the example, a grower who finds a source of lime that the dealer says is 70% ENV must apply 5.7/7.0 = 8.1 tons per acre. Lime should be applied one year prior to planting.

Table 16 and table 17 should be used in conjunction with the soil test results to determine the need for nutrients. Preplant nutrient requirements are similar for raspberries and strawberries.

Nutrition in Established Plantings

Use table 26 to determine the amount and timing of nitrogen application. Strawberries are not sensitive to nitrates or chlorides, so the use of balanced fertilizers is permissible.

Cornell University provides a leaf analysis service to growers. (Consult your county extension office for details.) Plants should be sampled after their first fruiting year and then every other year to monitor nutrient status. Occasionally, nutrient deficiency symptoms will occur. If symptoms appear in soils of pH 5.5 to 6.5, specific steps are recommended (table 27).

Table 25. Preplant lime recommendations to raise soil pH to 6.2 for strawberries

	Exchange acidity (me/100 grams soil)									
pH	*6*	*8*	*10*	*12*	*14*	*16*	*18*	*20*	*22*	*24*
	Tons of 100% ENV lime needed per acre									
4.4	2.7	3.6	4.4	5.3	6.2	7.1	7.9	8.8	9.7	10.4
4.6	2.6	3.5	4.4	5.2	6.1	7.0	7.8	8.7	9.5	10.4
4.8	2.6	3.4	4.3	5.1	6.0	6.8	7.6	8.5	9.3	10.2
5.0	2.5	3.3	4.1	4.9	5.7	6.5	7.3	8.1	9.0	9.8
5.2	2.3	2.7	3.8	4.5	5.3	6.0	6.8	7.5	8.3	9.0
5.4	1.7	2.3	2.8	3.4	3.9	4.5	5.0	5.6	6.1	6.7
5.6	1.7	1.6	2.0	2.4	2.8	3.2	3.6	4.0	4.4	4.8
5.8	1.2	1.2	1.4	1.7	2.0	2.3	2.6	2.8	3.1	3.4
6.0	0.9	0.6	0.8	0.9	1.0	1.2	1.3	1.5	1.6	1.7

Table 26. Nitrogen (lb/A) recommendations for strawberries

Month	*June-bearers*	*Day-neutral everbearers*
Planting year		
June		20
July	30	20
Aug		20
Sept	20	20
Fruiting years		
May		20
Jun		30
July	80	30
Aug		30
Sept	20	20

NOTE: Rates may be increased 25% if site is sandy, heavily mulched, or receives excessive rainfall.

Table 27. Nutrient deficiency symptoms and recommendations for strawberries on mineral soils

Element	*Deficiency symptom*	*Recommendation*
Nitrogen	Undersized, yellowish-green foliage; tips of oldest leaves become red, few runners; stiff petioles	80 lb/A actual nitrogen applied at renovation. 240 lb/A ammonium nitrate is optional
Potassium	Leaf margins become reddish from tips inward, basal portion remains green; short, slender runners	70 lb/A actual potassium applied at renovation
Phosphorus	Stunted, dark green foliage with purple coloration first appearing on older leaves; limited runner growth.	300 lb/A 20% superphosphate applied at renovation, or 150 lb/A triple phosphate
Magnesium	Reddish coloration between veins, extending toward midrib; appears first on older leaves	250 lb/A Epsom salts applied at renovation
Calcium	Tip burn in folded leaves emerging from the crown; brown, necrotic bands on runners	5,000 lb/A limestone if pH is below 5.5; 1,000 lb/A calcium sulfate if pH is above 5.5
Boron	Tip burn at growing points, excessive root branching and stubbiness; short stunted runners	1.5 lb/A solubor applied as a foliar spray to new leaves emerging after renovation

Cultivar Selection

Table 28. Recommended strawberry cultivars for New York

	Relative yield	*Berry size*	*Firmness*	*Freezing quality*	*Red stele resistance*	*Verticillium wilt resistance*	*Cold hardiness*
Early							
Earliglow	2	2	3	3	3	2	2
Lester	2	3	3	1	3	1	2
Midseason							
Allstar	3	3	3	3	3	2	2
Guardian	2	2	3	1	3	3	2
Holiday	2	3	3	3	1	2	2
Honeoye	3	3	2	3	1	2	3
Jewel	2	3	2	3	1	1	3
Kent	3	2	2	2	?	?	3
Midway	2	2	2	2	3	1	3
Raritan	3	3	2	1	1	1	3
Redchief	2	2	3	3	3	2	1
Scott	3	3	3	3	3	3	2
Late							
Bounty	3	2	2	2	1	1	2
Canoga	2	3	3	3	1	1	2
Delite	3	3	1	1	3	3	3
Fletcher	2	2	2	3	1	1	3
Micmac	2	3	2	2	1	1	3
Day-neutrals							
Tribute	3	2	2	2	3	3	2
Tristar	3	1	2	2	3	3	2

NOTE: Scale 3-excellent, 2-good, 1-fair.

Insects and Diseases

Botrytis Fruit Rot (Gray Mold)

Symptoms Rot usually begins at the blossom end or where the berry is touching another rotten berry. The infected portion is firm and brown while the berry is still green, but it expands and softens as the fruit ripens. A powdery gray mass of spores will cover infected berries if the weather remains humid and /or air circulation is poor.

Control Fungicide sprays as outlined in table 30. Because the fungus usually enters berries through infected blossom parts, it is important to begin a fungicide program at bloom. Fungicide protection programs are especially recommended if frost injury has occurred during bloom, for such blossoms are particularly susceptible to infection. Similarly, continued wet weather during bloom is especially conducive to disease development. Continued protection of fruit through harvest is most necessary during prolonged periods of wet, foggy, or humid weather. Disease control is also greatly aided by controlling weeds and regulating plant density to promote good air circulation and rapid drying of fruit.

Leaf Spot

Symptoms Small (about 1/8 inch in diameter) gray or tan spots surrounded by a purple border. May also appear on the petiole (leaf stalk).

Control Fungicide sprays, as outlined in table 30, are likely to be necessary only on susceptible varieties such as Catskill, Sunrise, Raritan, Honeoye, Midway, Sparkle, Jerseybelle, Veestar, Micmac, Tribute, and Kent. Heavy leaf infection can inhibit the production of flower buds for the following year and predispose a plant to winter injury.

Leaf Scorch

Symptoms Dark purple spots about 1/8-1/4 inch in diameter scattered over upper leaf surface or petioles. Differs from leaf spot in that spots are purple throughout (no light centers). Numerous infections may cause a leaf to appear red or light purple and eventually to dry up and appear scorched.

Control Same as leaf spot. Susceptible varieties include Raritan, Midway, Sparkle, and Jerseybelle.

Red Stele

Symptoms Symptoms usually appear just before harvest. Infected plants appear stunted and off-color and will frequently wilt and collapse if the weather becomes warm and dry. Because these same symptoms can be caused by other factors that destroy roots (such as root-feeding insects), diagnosis requires an examination of the plant's root system. Roots will have a "rat-tail" appearance caused by a loss of fine, branched feeder roots off the main fleshy roots. The main fleshy roots will be rotted from the tips back towards the crown. Cutting or scraping away the white outer portion just above the rotten zone will sometimes reveal a reddish root core (stele). Infected plants usually appear in groups and are frequently found in the lowest or wettest parts of a field.

Control Because red stele is caused by a soilborne fungus that persists for many years even when strawberries are no longer grown, never plant susceptible varieties in a field where the disease has occurred. Resistant varieties include Earliglow, Sunrise, Redchief, Midway, Scott, Guardian, Allstar, Tribute, Tristar, Surecrop, and Sparkle. These varieties, however, are not resistant to all races of the red stele fungus, so disease may still occur if a race to which they are not resistant is present. Because significant activity of the red stele fungus occurs only while the soil is extremely wet, plant only on a well-drained site or provide supplemental drainage if possible. Growing strawberries in raised bed culture will also reduce disease severity.

Verticillium Wilt

Symptoms Plants are affected most severely during their first year of growth. Outer leaves become brown and eventually collapse, but inner leaves remain green until the plant dies. This symptom distinguishes Verticillium wilt from other root and crown disorders.

Control In problem areas, plant only varieties resistant to Verticillium wilt (table 28). If susceptible varieties are to be planted where this disease is a likely problem (especially where potatoes, tomatoes, eggplants, or peppers have recently been grown, and, to a less extent, in recent squash, cucumber, or melon fields), fumigation with †Vorlex at 35 gallons per acre or with a †methyl bromide-†chloropicrin mixture is recommended. These materials also control nematodes and certain root-rotting organisms and weeds. Fall application is recommended to avoid the delay in planting which is necessary for proper aeration following spring application. Many weeds are also hosts of the *Verticillium* fungus, particularly nightshade, groundcherry, redroot pigweed, and lambsquarters. These weeds should be strictly controlled in future and current planting sites to keep the *Verticillium* population low.

Powdery Mildew

Symptoms The edges of infected leaves roll up, revealing a white, powdery growth on the lower leaf surface. Purple to reddish blotches also occur frequently on the lower leaf surface. Symptoms are usually not evident until middle or late summer.

Control Chemical control efforts have been largely ineffective. Because Guardian and Earliglow (and to a lesser, Raritan) are the only varieties commonly affected in New York, the disease can largely be avoided by not planting these varieties. The actual yield losses caused by mildew, however, are presumed to be slight, therefore one should not avoid planting any variety simply to control mildew.

Table 29. Spray calendar for control of strawberry pests after planting (first growing season)

Disease or insect	*Pesticide*	*Rate of product per acre*	*Comments or suggestions*
Potato leafhopper	†parathion 15WP	3 lb	Apply when leafhoppers first appear (usually in early to mid-June).
Twospotted spider mite	cyhexatin 50WP *or* dicofol* 35WP *or* 18.5EC	¾-1 lb 1 ½ lb 2 qt	Annual problem in the milder growing areas of New York State such as the lower Hudson Valley and Long Island. Only an occasional problem in upstate New York. Maximum underleaf coverage important. Repeat at 7-10-day intervals as necessary.

†Materials preceded by a dagger require certification for purchase.
*Dicofol use may be canceled in 1987, check registration status before using.

Table 30. Spray calendar for control of strawberry pests during fruiting years

Disease or insect	*Pesticide*	*Rate of product per acre*	*Comments or suggestions*
	Early spring *(when leaves are expanded and blossom buds are visible in the crown)*		
Twospotted spider mite	See recommendations and remarks in table 29.		
Bud weevil (clipper)	chlorpyrifos 4E *or* †parathion 15WP *or* †azinphos methyl 50WP *or* methoxychlor 50WP	2 pt 3 lb 1 lb 2-3 lb	Essential to treat when blossom buds first become visible in crown and temperature approaches 65° F. *Note:* Chlorpyrifos can only be used prebloom; limited to 2 applications per season. Methoxychlor is less effective than other insecticides listed but suitable for use during blossom period and by homeowner
Leaf spot, leaf scorch	thiram 65WP *or* captan 50WP	3 lb 3 lb	This spray is recommended primarily when disease carryover from the previous year is high and the weather is wet.
	Prebloom *(just before blossoms open)*		
Bud weevil (clipper)	Same material as for early spring		
Tarnished plant bug	†parathion 15WP 8EC *or* †endosulfan 3EC *or* malathion 25WP	3lb ½ pt 1 qt 4 lb	
Spittlebug	†endosulfan 3EC *or* methoxychlor 50WP	1 qt 2-3 lb	
Botrytis fruit rot (gray mold), leaf spot, leaf scorch	vinclozolin 50WP *or* captan 50WP *or* thiram 65WP *or* folpet 50WP *or* benomyl 50WP *plus* captan 50WP *or* thiophanate-methyl 70WP *plus* captan 50WP	1 ½-2 lb 6 lb 5 lb 4 lb ½ lb 3 lb ½ lb 3 lb	**Blossom** protection is an extremely important component of a fruit rot protection program. Thorough coverage is essential for good disease control. Vinclozolin (Ronilan) is the most effective fungicide against gray mold, but it has little activity against leaf spot and leaf scorch.
	Full bloom		
Botrytis fruit rot, leaf spot, leaf scorch	Same materials and rates as preloom. DO NOT APPLY INSECTICIDES during bloom.		

Continued on next page.

Table 30. Spray calendar for control of strawberry pests during fruiting years *(continued)*

Disease or insect	*Pesticide*	*Rate of product per acre*	*Comments or suggestions*
		Fruit set through harvest	
Botrytis and other fruit rots, leaf spot, leaf scorch	vinclozolin 50WP	1 ½-2 lb	Apply at 7-14-day intervals through harvest. Frequent applications are most necessary during prolonged wet, humid, and cool weather. If leather rot should become a problem, folpet or captan will provide some control.
	or benomyl 50WP	6 oz	
	plus		
	captan 50WP	3 lb	
	or folpet 50WP	4 lb	
	or thiram 65WP	4-5 lb	
	or thiophanate-methyl 70WP	6 oz	
	plus		Mixing fungicides reduces the possibility of developing resistance and provides broader control of diseases such as leather rot.
	captan 50WP	3 lb	
	or captan 50WP	6 lb	
Tarnished plant bug	malathion 25WP	4 lb	Apply at 7-14-day intervals through harvest. Three-day preharvest interval.
		Postharvest	
Leaf spot, leaf scorch	thiram 65WP	3 lb	Apply at monthly intervals if disease pressure is high. Severe leaf spot predisposes plants to winter injury and provides inoculum for the following year.
Rootweevil	†carbofuran 4F	2 qt/A of surface sprayed	Apply in a 12-in band over the row after renovation in late July. Will also provide some control of bud weevil adults. This is a 24(c) SLN registration; the applicator must have a copy of the supplemental label in his or her possession. Plow under old beds as soon as possible to prevent insect spread to new beds. Do not cut off old foliage during renovation of beds to be held over. Do not use on Long Island.
		Special sprays	
Cyclamen mite	†endosulfan 3EC	3 qt	Apply just before bloom. Drench crowns, using a minimum of 200 gal dilute spray/A. Avoid infested planting stock. Do not use †endosulfan more than once during blossom period or within 4 days of picking. Good control can be achieved postharvest after the old foliage is cut off. This spray will also control tarnished plant bug, spittlebug, and aphids.
Leafrollers	†parathion 15WP	3 lb	Just before bloom. Diazinon should be used if control is necessary during the blossom period. Will also control tarnished plant bug. †Parathion may increase severity of cyclamen mite infestation.
	or diazinon 50WP	1 lb	
Aphids	†endosulfan 3EC	1 qt	Just before bloom. Aphids may build up where dicofol was used for spider mite control.

†Materials preceded by a dagger require certification for purchase.

Black Root Rot

Symptoms Over time, plant vigor and productivity decline. Feeder rootlets are killed extensively, and fleshy structural roots deteriorate and become blackened. Blackening frequently starts as patches along the length of the root, rather than from the tip back.

Control There is no single, defined cause of black root rot; therefore, there is no single control recommendation. Cultural practices that reduce soil compaction, improve aeration, and promote good drainage are frequently beneficial. Rotating a field out of strawberries for at least 2 years before replanting is strongly recommended as a measure for minimizing black root rot damage. Preplant fumigation, using mixtures containing 17%-33% †chloropicrin plus †methyl bromide or chlorinated hydrocarbons (e.g., †Vorlex), effectively controls the major microorganisms associated with the black root rot complex.

Leather Rot

Symptoms Affected fruits appear dull and lifeless. Infected areas on immature fruit appear brown, whereas those on maturing fruit appear bleached out. Infected areas are tough and leathery and are discolored on the inside as well as the outside of the fruit. Infected fruit have a bitter, unpleasant taste.

Control Leather rot is promoted by abundant relatively warm rains during the fruiting period. When

these conditions occur, fungicide sprays containing folpet or captan will provide some control. Disease incidence will also be reduced by controlling weeds and plant densities, thereby promoting rapid drying of the fruit after a rain.

Potato Leafhopper

Symptoms Adults migrate into the state in early to mid-June, carried by summer weather fronts. The adults and nymphs feed along the veins on the undersides of leaves by sucking plant juices and, in the process, inject a toxic substance with their saliva. Affected plants have shorter petioles and smaller leaves, which bend down at right angles and are generally distorted. Leaf yellowing is also seen, starting at the margins and progressing toward the midvein.

Control A broad-spectrum insecticide (see table 29) applied when the leafhoppers first appear should provide control.

Twospotted Spider Mite

Symptoms In early spring, mites begin feeding on the undersides of new leaves; this may result in small yellow spots on the upper leaf surfaces, but these symptoms do not occur in all cases and are not seen later in the year. More characteristic of damage are brownish, dry areas on the lower leaf surfaces, and then later the entire lower leaf may become dry and brown, giving it a bronzed appearance. Heavily infested plants look dry and stunted, and sparse new growth is rather yellowish and distorted. Damage is first seen and is more prevalent in drier areas of a field; milder growing areas (Hudson Valley and Long Island) experience problems with mites most frequently.

Control Chemical control of spider mites is often not completely effective because of their high mobility, reproductive rate, and resistance to some pesticides. Good coverage of the plants is critical for adequate protection, particularly on undersides of the leaves; use adequate water (200-300 gal/A) for maximum effectiveness of your miticide (see table 29). Regular leaf monitoring is necessary for assessing population growth.

Strawberry Bud Weevil (Clipper)

Symptoms Adults puncture blossom buds while feeding in the spring, deposit eggs in the nearly mature buds, and then girdle the bud so that it hangs by a mere thread or falls to the ground. Injury is most likely when strawberries are grown next to woodlots or other sites suitable for adult hibernation.

Control Timing of pesticide applications is extremely critical. Treatment must take place when blossom buds first become visible in the crown and the temperature approaches 65° F; weevils can do much damage in a short period of time if these favorable temperatures coincide with bud availability. Frequent scouting for bud cutting is important in areas where weevil pressure is expected to be high; more than 1 cut bud per linear foot of row would warrant treatment. Mulches and full-canopy beds may encourage newly emerged adults to remain in the planting, so that damage increases in succeeding years. Cropping systems shorter than 3 years, plowing under of all old beds immediately after the final harvest, and removing the foliage and mulch to reduce the suitability of overwintering sites help lessen the chances of clipper damage.

Tarnished Plant Bug

Symptoms This pest is one cause of "catfaced" or "button" berries. It damages fruit by feeding on the flower bud, so that the berry stops developing in the immediate area of the feeding damage. Little information is available on cultivar differences in susceptibility to tarnished plant bug, but early maturity is correlated with freedom from injury, whereas later cultivars may suffer more heavy damage.

Control Any time from just before the blossoms open until harvest, check for tarnished plant bug nymphs by striking the plant over a flat, low-sided (light-colored) dish. One of the materials listed in table 30 can be used for control if 1-2 nymphs are found per plant; note that malathion may be used up to 3 days before harvest.

Spittlebug

Symptoms White, frothy masses on the stems and leaves around the time of bloom hide the nymphs, which pierce the stems and suck plant juices. This feeding, if extensive, can stunt the plants and reduce berry size; leaves appear crinkled and darker green than undamaged leaves. The spittle masses tend to be a great nuisance to pickers.

Control A prebloom insecticide as outlined in table 30 will provide control. Populations are usually worst in weedy fields; only one generation is produced per year, and leaves recover after the insects leave.

Root Weevils

Symptoms Different species, but most commonly the strawberry root weevil, black vine weevil, and rough strawberry root weevil, attack the roots or crowns of plants in the grub stage. All have a 1-year life cycle, although some of the beetles are known to live two seasons. Adults emerge about late June; beds with heavy infestations show distinct patches or spots that are stunted in appearance and have substantially reduced yield. The roots of injured plants are badly eaten away by the grubs, and continued infestation may completely destroy the plant.

Control Use carbofuran (Furadan) sprayed over the row after renovation in late July, as outlined in table 30.

Cyclamen Mite

Symptoms This tiny (1/100 inch) mite is shiny pinkish orange when mature; the translucent eggs are often so abundant that they appear as a white mass along the midveins of the folded, newly emerging leaves.

Feeding activity on these young leaves in the plant crown causes them to appear stunted, crinkled, and malformed when they emerge. Blossom feeding later results in misshapen fruit. These mites are more of a problem where strawberry beds are kept for long periods. Numbers start to increase during bloom and reach a peak during fruit development.

Control If mites are regularly a problem, apply †endosulfan (Thiodan) just before bloom as noted in table 30. Alternatively, an application during bed renovation can more easily reach the mites in the crown leaves after the old foliage is cut off. Note the restrictions on frequency of use.

Leafrollers

Symptoms Several species of moth larvae roll or fold strawberry leaves with silk. This type of leaf injury may be seen throughout the season, but an extremely large population is required before noticeable damage occurs to the crop.

Control Note the special spray prebloom recommendations in table 30.

Aphids

Symptoms These soft-bodied insects usually occur on new shoots and buds in the crown of the plant and also along the veins on the undersides of leaves. When present in large numbers, they weaken the plant, and their honeydew promotes the growth of black sooty mold, which makes the fruit and leaves sticky, hindering harvest and reducing salability. More importantly, aphids are vectors for several serious virus diesases.

Control A spray against aphids may be elected just before bloom; however, many pesticides effective against aphids are also toxic to predators of cyclamen mites and spider mites. Refer to table 30.

Weed Control

Chemicals should be selected on the basis of particular weed problems. Not all chemicals are required on all fields (table 36). Many growers find that napropamide in late fall and 2,4-D at renovation provide reasonable weed control. Others use terbacil immediately after mowing in July.

Weed control chemicals for day-neutral strawberries are limited to a November application of diphenamid, 2,4-D, terbacil, or napropamide.

Table 31. Herbicides registered for use on strawberries in New York State

Days to harvest	Herbicide	Rate/A: Formulation	Rate/A: lb AI	Remarks
42	DCPA (Dacthal)	75WP (8-12 lb)	6-9	Apply after planting before weeds emerge during the growing season, or immediately after mulch removal.
60	diphenamid (Enide) (Dymid)	50WP (8-12 lb) 80W (5-7.5 lb)	4-6	Apply 2 weeks after planting. Apply before weeds emerge. Use 4 lb AI for new plants, 6 lb AI for established plants in fall or after harvest.
60	chloroxuron (Tenoran)	50WP (8 lb)	4	Apply on germinating seedling weeds. Also effective on established chickweed.
–	2,4-D (Dow Formula 40)	4 lb/gal (1-3 pt)	0.5-1.5	For broadleaf weeds in established plantings. Apply soon after last picking or when berry plants are dormant in mid-fall (Nov).
70	terbacil (Sinbar)	80WP (0.5-1.25 lb)	0.4-1	Apply soon after harvest before new growth begins or in dormant season from mid-fall to late winter. Treat only plants established for 6 months or more. Do not use on soils with less than 2% organic matter. Not recommended for use on 'Guardian' or 'Micmac'.

(continued on next page)

Table 31. Herbicides registered for use on strawberries in New York State *(continued)*

Days to harvest	Herbicide	Formulation	Rate/A lb AI	Remarks
42	napropamide (Devrinol)	50WP (8 lb)	4	Apply in late fall or early spring before seedling weeds emerge or after adequate numbers of runners have rooted. Rainfall is necessary for activation.
365	fluazifop (Fusilade 2000)	1E (¾-1 ½ pt)	0.09-0.19	Apply to grasses at 2"-8" growth stage in spring. Does not control broadleaf weeds. Nonbearing plantings only.

Table 32. Weed control calendar for June-bearing strawberries

Planting year		Fruiting year	
Month	Chemicals	Month	Chemicals
Apr-May	DCPA, diphenamid, or fluazifop	Apr	DCPA or diphenamid
June-Aug	chloroxuron	July	2,4-D, chloroxuron, or terbacil
Nov	napropamide or diphenamid	Nov	2,4-D, terbacil, diphenamid, or napropamide

Cultural Timetable

Table 33. Cultural timetable for strawberries

Date	Procedure
June-bearers	
Planting year	
Apr	Set plants, apply preemergent herbicide
May-June	Remove flowers lightly fertilize
July-Sept	Set runners in row, lightly fertilize
Oct	Narrow rows to 12 inches
Fruiting year	
June	Harvest fruit
July	Renovate (mow off leaves), fertilize
Aug	Sample for leaf analysis
Sept	Lightly fertilize
Oct	Narrow rows to 12 inches
Day-Neutrals	
Planting year	
Apr	Set plants
May	Remove flowers
June	Remove flowers, lightly fertilize
July	Lightly fertilize
Aug	Harvest fruit, lightly fertilize
Sept	Harvest fruit, lightly fertilize
Nov	Apply herbicides
Fruiting year	
June-Sept	Harvest fruit, fertilize
Nov	Apply herbicides

Supplemental Information

Herbicides

Table 36. Effectiveness of herbicides on weeds

Herbicide	*Annual grasses*	*Perennial grasses*	*Annual broad-leaves*	*Perennial broad-leaves*	*Comments*
Chloroxuron	Fair	Poor	Good	Poor	Excellent control of chickweed; good preemergent control of lambsquarters, pigweed, mustards, nettle, barley. Moderately expensive.
chlorpropham	Good	Poor	Good	Poor	Excellent preemergent control of chickweed; good control of barnyardgrass, carpetweed, crabgrass, foxtail, mustards, and smartweeds. Activity is prolonged by simultaneously applying chemical protectant PPG-124. Moderately expensive.
2,4-D	Poor	Poor	Good	Good	Excellent postemergent control of morning glory, cocklebur, lambsquarters, pigweed, ragweed, and smartweed. Good control of dandelion. Inexpensive.
DCPA	Good	Poor	Fair	Poor	Excellent preemergent control of annual grasses and purslane, carpetweed, chickweed, and lambsquarters. Moderately expensive.
dichlobenil	Good	Good	Good	Good	Good preemergent control of a wide range of annual and perennial species, including ferns, rushes, and sedges. Very expensive.
diphenamid	Good	Poor	Good	Poor	Good preemergent control of bluegrass, crabgrass, fall panicum, foxtail, ryegrass, lambsquarters, pigweed, smartweed, chickweed, carpetweed. Moderately expensive.
fluazifop	Good	Fair	Poor	Poor	Postemergent control of all annual grasses and bermudagrass, johnsongrass, quackgrass, and wirestem muhly. Moderately expensive.
napropamide	Good	Poor	Fair	Poor	Preemergent control of most annual grasses and chickweed, knotweed, thistle, and sorrel. Moderately expensive.
norflurazon	Good	Poor	Good	Poor	Will suppress nutsedge and perennial grasses. Preemergent control of other grasses.
oryzalin	Good	Poor	Fair	Poor	Preemergent control of most grasses and lambsquarters, pigweed, purslane. Moderately expensive.
†paraquat	Good	Poor	Good	Poor	Kills annual weeds and the tops of perennial weeds. Moderately expensive.
pronamide	Good	Good	Fair	Poor	Controls annual bluegrass at all stages of growth. Excellent preemergent control of ryegrass, barnyardgrass, orchardgrass, foxtails, and nightshade. Partial suppression of quackgrass.
sethoxydim	Good	Good	Poor	Poor	Excellent postemergent control of most annual and perennial grasses.
simazine	Fair	Poor	Good	Poor	Preemergent control of most broadleaf weeds and bluegrass, ryegrass, and crabgrass. Inexpensive.
terbacil	Good	Fair	Good	Poor	Preemergent control of chickweed, crabgrass, foxtail, henbit, lambsquarters, marestail, peppergrass, ryegrass, shepherdspurse, mustards, yellow rocket, prickly lettuce, nightshade, knotweed, ragweed, and smartweed and partially controls quackgrass, nutsedge, and sorrel. Moderately expensive.

†Materials preceded by a dagger require certification for purchase.

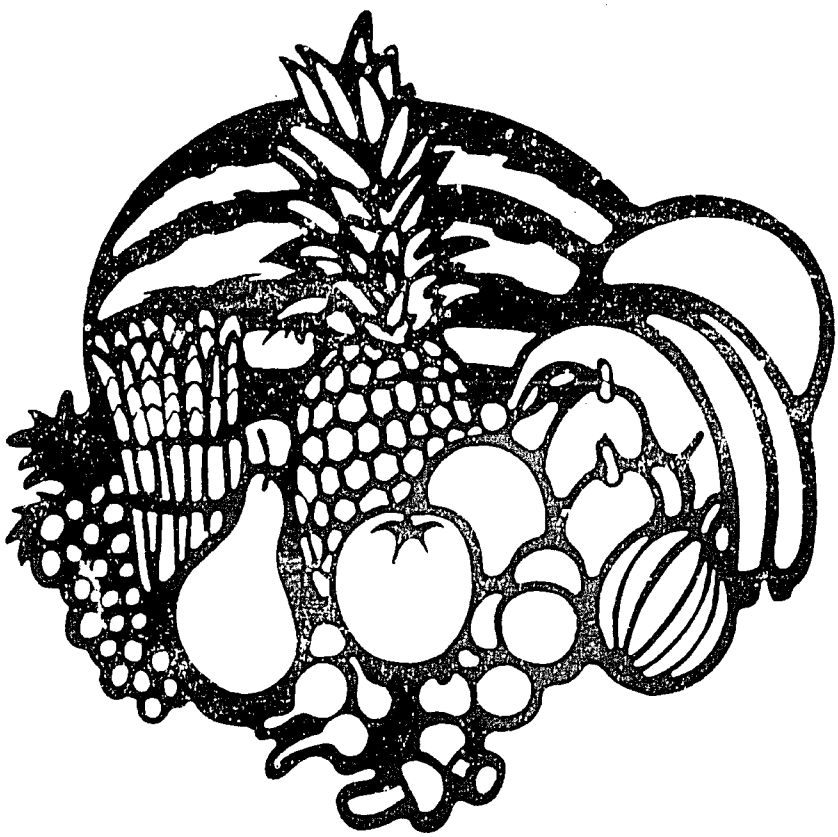
United States
Department of
Agriculture

Agricultural
Marketing
Service

Washington, D.C.

United States Standards for Grades of Strawberries

Effective July 1, 1965



UNITED STATES STANDARDS FOR GRADES OF STRAWBERRIES[1]

SOURCE: 30 FR 6711, May 18, 1965, unless otherwise noted. Redesignated at 42 FR 32514, June 27, 1977 and at 46 FR 63203, Dec. 31, 1981.

Effective July 1, 1965

GRADES

Sec.
51.3115 U.S. No. 1.
51.3116 U.S. Combination.
51.3117 U.S. No. 2.

UNCLASSIFIED

51.3118 Unclassified.

APPLICATION OF TOLERANCES

51.3119 Application of tolerances.

DEFINITIONS

51.3120 Overripe.
51.3121 Undeveloped.
51.3122 Damage.
51.3123 Serious damage.
51.3124 Diameter.

AUTHORITY: The provision of this subpart issued under secs. 203, 205, 60 Stat. 1087, as amended, 1090 as amended; 7 U.S.C. 1622, 1624.

GRADES

§ 51.3115 U.S. No. 1.

"U.S. No. 1" consists of strawberries of one variety or similar varietal characteristics with the cap (calyx) attached, which are firm, not overripe or undeveloped, and which are free from mold or decay and free from damage caused by dirt, moisture, foreign matter, disease, insects, or mechanical or other means. Each strawberry has not less than three-fourths of its surface showing a pink or red color.

(a) *Size.* Unless otherwise specified, the minimum diameter of each strawberry is not less than three-fourths inch.

(b) *Tolerances.* In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects.* Not more than 10 percent for strawberries in any lot which fail to meet the requirements of this grade, but not more than one-half of this tolerance, or 5 percent, shall be allowed for defects causing serious damage, including therein not more than two-fifths of this latter amount, or 2 percent, for strawberries affected by decay.

(2) *For off-size.* Not more than 5 percent for strawberries in any lot which are below the specified minimum size.

§ 51.3116 U.S. Combination.

"U.S. Combination" consists of a combination of U.S. No. 1 and U.S. No. 2 strawberries, except for size: *Provided,* That at least 80 percent, by volume, of the strawberries meet the requirements of U.S. No. 1 grade.

(a) *Size.* Unless otherwise specified, the minimum diameter of each strawberry is not less than three-fourths inch.

(b) *Tolerances.* In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects.* Not more than 10 percent for strawberries in any lot which are seriously damaged, including therein not more than one-fifth of this tolerance, or 2 percent, for strawberries affected by decay. No part of any tolerance shall be allowed to reduce for the lot as a whole, the percentage of U.S. No. 1 strawberries required in the combination, and individual containers (cups or baskets) may have not less than 65 percent U.S. No. 1 strawberries: *Provided,* That the entire lot averages within the required percentage.

(2) *For off-size.* Not more than 5 percent of the strawberries in any lot may be below the specified minimum size.

§ 51.3117 U.S. No. 2.

"U.S. No. 2" consists of strawberries which are free from decay and free from serious damage caused by dirt, disease, insects, mechanical or other means. Each strawberry has not less than one-half of its surface showing a pink or red color.

(a) *Size.* Unless otherwise specified, the minimum diameter of each strawberry is not less than five-eighths inch.

(b) *Tolerances.* In order to allow for variations incident to proper grading and handling the following tolerances, by volume, are provided as specified:

(1) *For defects.* Not more than 10 percent for strawberries in any lot which are seriously damaged, including therein not more than three-fourths of this tolerance, or 3 percent, for strawberries affected by decay.

(2) *For off-size.* Not more than 5 percent for strawberries in any lot which are below the specified minimum size.

UNCLASSIFIED

§ 51.3118 Unclassified.

"Unclassified" consists of strawberries which have not been classified in accordance with any of the foregoing grades. The term "unclassified" is not a grade within the meaning of these standards but is provided as a designation to show that no grade has been applied to the lot.

APPLICATION OF TOLERANCES

§ 51.3119 Application of tolerances.

(a) The contents of individual packages (cups or baskets) in the lot, based on sample inspection, are subject to the following limitations:

(1) For a tolerance of 10 percent or more, individual packages (cups or baskets) in any lot shall have not more than one and one-half times the tolerance specified, except that when the package contains 25 specimens or less, individual packages shall have not more than double the tolerance specified: *Provided,* That the averages for the entire lot are within the tolerances specified for the grade.

(2) For a tolerance of less than 10 percent, individual packages (cups or baskets) in any lot shall have not more than double the tolerance specified, except that at least one defective and one off-size specimen may be permitted in any package: *Provided,* That the averages for the entire lot are within the tolerances specified for the grade.

DEFINITIONS

§ 51.3120 Overripe.

"Overripe" means dead ripe, becoming soft, a condition unfit for shipment and necessitating immediate consumption.

§ 51.3121 Undeveloped.

"Undeveloped" means that the berry has not attained a normal shape and development due to frost injury, lack of pollination, insect injury, or other causes. "Button" berries are the most common type of this condition.

§ 51.3122 Damage.

"Damage" means any defect or any combination of defects, which materially detracts from the appearance, or the edible or shipping quality of the strawberries.

§ 51.3123 Serious damage.

"Serious damage" means any specific defect described in this section; or an equally objectionable variation of any one of these defects, any other defect, or any combination of defects, which seriously detracts from the appearance, or the edible or shipping quality of the strawberries. The following specific defects shall be considered as serious damage:

(a) Soft berries;
(b) Badly deformed berries;
(c) Badly bruised berries;
(d) Decayed or leaky berries;
(e) Berries badly caked with dirt; and,
(f) Berries with less than one-half of surface showing pink or red color.

§ 51.3124 Diameter.

"Diameter" means the greatest dimension measured at right angles to a straight line running from the stem to the apex.

The United States Standards for Grades of Strawberries contained in this subpart shall become effective July 1, 1965, and will thereupon supersede the United States Standards for Strawberries which have been in effect since March 23, 1942.

Dated: May 12, 1965.

G. R. GRANGE,
Deputy Administrator,
Marketing Services.

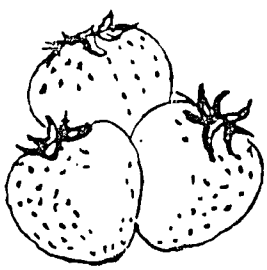
[FR Doc. 65-5197; Filed, May 17, 1965; 8:46 a.m.]

[1] Compliance with the provisions of these standards shall not excuse failure to comply with the provisions of the Federal Food, Drug and Cosmetic Act, or with applicable State laws and regulations.

Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

HANDLING STRAWBERRIES FOR FRESH MARKET

by F G MITCHELL
E C MAXIE
A S GREATHEAD



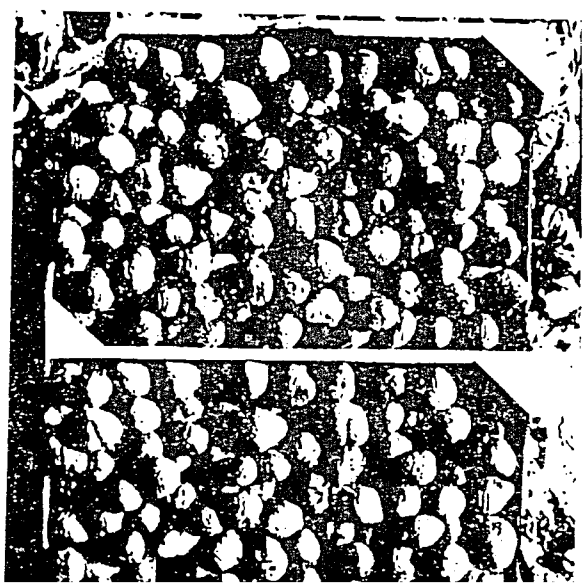
CALIFORNIA AGRICULTURAL
Experiment Station
Extension Service

CIRCULAR 527

Did you know that . . .

- An estimated $5,000,000 worth of California strawberries are discarded between the field and the table each year?
- Each handler of strawberries, from the grower to retailer, may do damage which he does not see?
- Deterioration can come from three sources—injuries, self-destruction and decay?
- Any program aimed at reducing market losses of strawberries must start with careful picker training and supervision?
- Berries held at 50° F will last only one fourth to one half as long as fruits held at 32° F?
- Berries exposed to the sun after picking quickly reach temperatures considerably above air temperature?
- Short delays at field temperatures before cooling will reduce the amount of marketable fruit?

Properly harvested crate of high quality strawberries.



MAY, 1964

The Authors:

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HANDLING STRAWBERRIES FOR FRESH MARKET

F. G. MITCHELL · E. C. MAXIE · A. S. GREATHEAD

THIS CIRCULAR is intended as a guide for growers, shippers, and other handlers of fresh strawberries. It tells how to prepare and handle California strawberries for fresh market. Advice given will pertain to berries going into any fresh outlet but certain steps in the operation may not be as critical when the berries are marketed locally (and quickly).

High fruit quality in the market is only possible if fruit of high quality is produced in the field. This places responsibility on the grower to use good cultural practices, such as irrigation, fertilization, weed control, pest and disease control, and to carefully supervise field operations to correct problems before they may affect fruit quality. (Alderman *et al.*, 1962, and Holland *et al.*, 1962).

THE PROBLEM

STRAWBERRIES are one of the most perishable of all fruits. They are essentially full-ripe at harvest as opposed to many other fruits that are picked "green" and ripened later. They have a high rate of metabolism (they "live fast") and will destroy themselves in a relatively short time, even without the presence of decay organisms.

Strawberries are living organisms. As all living things they must stay healthy, for their health determines the quality of the fruit the consumer receives.

The structure of the strawberry makes it vulnerable to spoilage. It has a thin, tender skin that is easily broken. The seeds are easily torn away, and the flesh of the fruit is soft, allowing it to be easily crushed and bruised. Any injury may invite an attack by decay organisms to which this fruit is very susceptible.

Thus, the strawberry fruit, having a high rate of metabolism, being susceptible to injury, and vulnerable to decay organisms in the field, is ready prey to many postharvest ills. Losses of California strawberries destined for eastern markets are staggering. During recent years it has been estimated that the equivalent of the yield of 2,000 acres become inedible annually before reaching the consumer. This means that $5,000,000 worth of our strawberries are discarded between field and table each year. In addition, a very important, but undetermined loss is the reduction in quality of fruits that are consumed, and its effect on sales volume and price.

Strawberry fruits begin to lose quality before they are harvested. When the sun rises on a field of strawberries

the ripe fruits start to deteriorate by decay or internal breakdown, and this deterioration continues until the fruit is eaten. The quality of the fruit when the consumer receives it, or even whether the fruit ever reaches him, depends on how good a job is done by the various handlers.

Each handler of strawberries, from the grower to the retailer, may do damage he does not see. Since the damage does not appear while the fruit is under his control he may not be held immediately responsible for it. However, any damage which results in loss of fruit or quality will affect ultimately the returns of all handlers of strawberries.

Importance of Temperature

The most important way to slow down spoilage of strawberries is to remove field heat and maintain the fruit at a low temperature. For maximum life, keep strawberries as close to 32° F as is practical.

Why is temperature so important? As stated before, a strawberry fruit will destroy itself even if it is free of disease organisms. When the temperature of a strawberry is raised from 32° to 50° F its rate of deterioration will increase two to four fold. *This means that fruits at 50° F have a life expectancy of only one fourth to one half that of fruits at 32° F.* If the temperature of the fruit is around 85-90° F, as may happen in packed berries left in an open field, the market life of the fruit is reduced to only a few hours.

Relative Humidity

The relative humidity at which strawberries are held will affect their weight loss and appearance. While relative humidities approaching saturation (100 per cent) may promote the development of decay organisms, too low a relative humidity for any extended period will increase weight loss and may quickly make the fruit look old and shriveled. To avoid this, hold the relative humidity at approximately 90 per cent.

Fruit Rots (Wilhelm, 1961).

Another important source of strawberry spoilage is fruit-rotting organisms. Fruit-rotting fungi can grow rapidly in a basket of berries and destroy the fruit. The rate and amount of decay in fruit may be greatly increased by injuries during picking or handling, and by delayed cooling.

Gray mold rot, caused by the fungus *Botrytis cinerea* Pers., is the most common of the fruit rots. Field infection by this organism is favored by cool, wet conditions. It is most serious during rainy periods and during cool, wet, or foggy weather. The organism causing the disease is present in every strawberry field at all times. It is the most common organism found in older leaf tissue. The disease causes severe losses in the field before harvest and also in storage and transit of the harvested fruit. Since the organism is able to penetrate the unbroken skin of the berry, one decayed fruit can lead to the decay of surrounding fruit, producing a "nest" of decayed berries.

An infected fruit first shows soft, dull colored spots. Later the fungus coats the fruit with its gray growth. During picking, spores from moldy fruit may contaminate healthy berries. Rotting may continue during transit and marketing, and any injury inflicted during picking or handling will favor the disease. Usually, gray-mold problems have their origin in the field.

A second disease of stored fruit is caused by the fungus *Rhizopus stolonifer* (Ehr. ex Fr.) Vuill. (= *R. nigricans* Ehr.) This disease is favored by high temperatures and humidity. Like gray mold, it causes severe losses in the field as well as in storage. Infected fruit is soft and watery, giving rise to the name "leak." Under conditions of high humidity, the organism will produce a long whiskery type growth on infected fruits, and like gray mold the organism can move from infected fruit into adjacent healthy fruit, producing the nesting effect.

While there are no commercial means of completely eliminating fruit rots, growers, shippers, and handlers can do much to minimize losses. For instance:

- Remove from the plant all fruit (green or ripe) showing signs of decay at each picking.
- Do not put any fruit showing decay into the crate. Fully instruct pickers accordingly.
- Apply fungicides in the field to reduce decay in field and storage. Consult the current University pest and disease control recommendations for detailed information.
- Cool the fruit as soon after harvest as possible and keep it cool. The lower the temperature, the slower the advance of these decay organisms. For best control, hold fruit as close to 32° F as possible.

HARVESTING AND FIELD HANDLING

PROPER SUPERVISION of the entire harvest operation is essential. This must include supervision of all aspects of the harvest—picking, field handling and local transport to the cooler.

Field supervision may be handled by the owner or manager of a small operation or by hired foremen of larger operations. Whatever the arrangements, these field bosses must be

Picking crew at work in strawberry field. Picking from o[illegible]ne half of the bed nearest to picker eliminates excessive reaching and simplifies selection of ripe berries.

Field picking of strawberries, showing desirable crate and basket arrangement. Note picking stand to keep crate out of dirt. The picker is picking, sorting, and packing in one operation, avoiding unnecessary handling. Picking from only the half of the bed nearest to picker eliminates excessive reaching and simplifies selection of ripe berries.

under careful control of management since their activities will have profound influence on the shipping quality of the fruit.

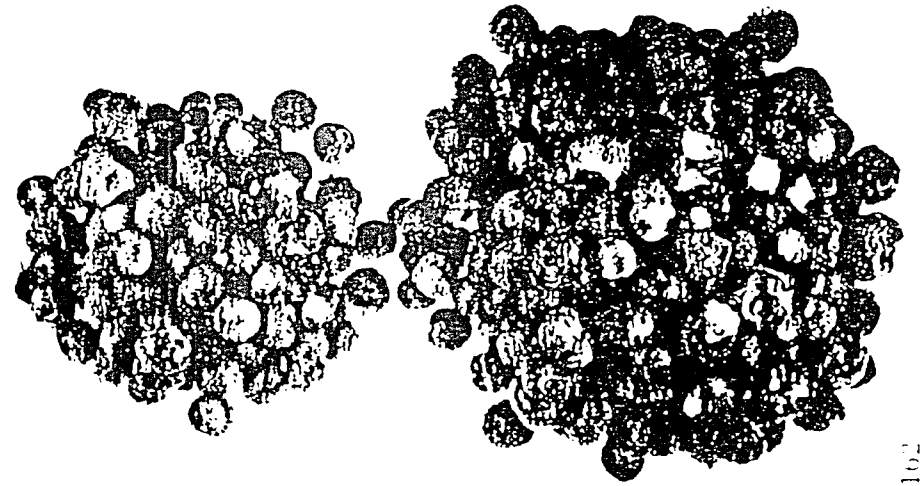
Picking

Strawberries are harvested at different stages of ripeness, depending on the time and distance to market (Holland *et al.*, 1962). Fruit for local market should be fully ripe and firm while fruit for long distance shipment should be picked at the pink or three-fourths colored stage.

Strawberries in California are almost universally shipped in fiber crates holding 12 one-pint baskets. Three main types of baskets are used—molded plastic, paper, and wood veneer. The plastic baskets are open for air movement and for visual inspection by the consumer. Paper baskets do not allow visual inspection, but provide some cushioning protection against rough handling. Wood-veneer baskets, no longer the primary container, are now used mainly for local-market berries. The fruit is picked directly into the crate in which it is to be shipped.

The following steps are important for pickers (Mitchell and Greathead, 1959):

- Always use a picking cart or stand, to keep the crate off the ground.
- Handle the full crate very gently. The tender fruit is very easily bruised.
- Be careful that feet and knees do not injure any green fruit hanging in the furrow. This can reduce the quality of later harvests.
- Pick berries with the caps (or calyx) on. Take hold of the fruit gently between the thumb and first two fingers. With an upward or forward twist of the wrist, snap the stem off. Pick special stem grade fruit by pinching the stem one to two inches from the calyx.
- Hold the fruit loosely in the hand without squeezing. Remember that any time you squeeze the fruit it is bruised and will discolor, so HANDLE IT GENTLY. Place the fruit in the crate—do not drop it. Do not hold too many fruit in the hand at one time.
- Throw away any berries showing rot, sunburn, insect injury, severe misshape, and also soft and overripe berries. Remove all of these berries from the plant and place them in the bottom of the furrow. If the cap has been removed accidentally, discard the berry.
- Do not fill the crates so full that berries will be crushed when crates are stacked.



Selection of berries by a careful picker resulted in 11.4 per cent unmarketable fruit (left) while a careless picker caused 33.7 per cent of the berries to be unsalable.

Picker damage can nullify all other attempts to maintain fruit quality. To check importance of picker damage, a test was set up to compare the level of marketable fruit from pickers with different abilities at picking, sorting and packing. Two pickers, selected by the grower, were set side by side in the field but were not told that their fruit was part of a test. Five crates were taken from each picker, identified, and then held for eight days at 41° F before sorting. The more careful picker's lot contained 11.4 per cent unmarketable fruit compared to 33.7 per cent for the less careful picker. This illustrates a wide variability in the care exercised by pickers. Any program aimed at reducing market losses of strawberries must start with thorough picker training and supervision.

The experienced picker will snap fruit without bruising the berry or breaking the cap.

Field Handling and Hauling

Problems in field handling of strawberries can include physical damage and inadequate protection against high temperature or delayed cooling. Most growers make a real effort to avoid rough handling of their fruit during picking, stacking, and loading. However, they may overlook good temperature management because the end results are not so immediately apparent. Nevertheless, temperature management in the field can strongly influence the ultimate quality and shelf life of the berries (Maxie *et al.*, 1959*a*, 1959*b*).

To determine the importance of temperature in strawberry management, it is necessary to understand the effect of temperatures on strawberry

Temperatures actually attained in the field

The upper left graph on page 9 shows the temperatures of strawberries in different positions in the crate and in shaded and sunny locations. Note the definite advantage of shading. Strawberries exposed directly to the sun quickly reach temperatures considerably above air temperature because their dark color readily absorbs heat from the sun. During long exposure, even berries in shaded positions ultimately reach temperatures approaching that of the air. You will face this situation under normal field conditions where temperatures are fairly high.

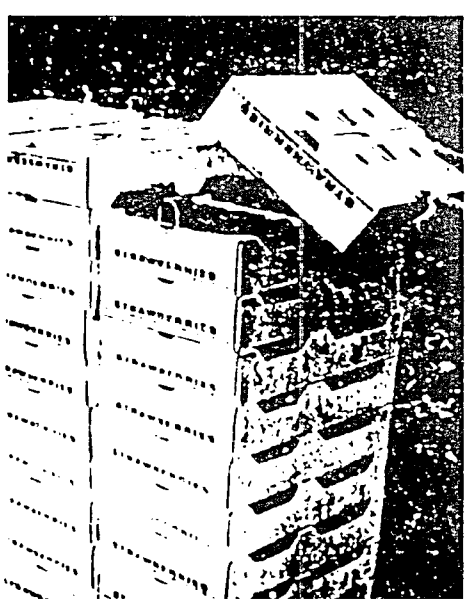
Effect of high temperatures on the berry

The upper right graph on page 9 shows the respiration rate of Shasta strawberries held at temperatures ranging from 32° to 100° F. As respiration rate roughly equals the rate of living of the berries it obviously is to your advantage to hold fruit at lower temperatures. Note the rapid drop of the respiration rate at higher temperatures, due to destruction and death of the tissue. It is important, therefore, to reduce the temperature of the fruit as soon as possible after harvesting.

Some growers hold their fruit in the field for prolonged periods. Obviously, at extremely high temperatures this will lead to rapid destruction of the fruit. However, if you pick the berries when it is fairly cool and if you shade them in the field, you can slow down their destruction to some extent. But they may warm up rapidly as a result of a warm summer breeze or during their transport on an open flat bed truck to the shipper's facility (lower left graph on page 9). An air velocity of just five miles an hour, a very mild wind, warms the fruit nearly to air temperature in 20 to 30 minutes. This rapid warming results from an unlimited supply of warm air passing directly over the fruit. As a result of cooling by the evaporation of water from the fruit, berries in the center of the basket, somewhat protected from air, are not warmed to the air temperature. This water loss, however, causes further reduction of fruit quality. A substantial temperature rise during a very short period of open transit will take hours to overcome in the normal pre-cooling facility, where both refrigeration capacity, air flow are limited.

To check the effect of delays in cooling upon marketability, berries were held for different periods of time following harvest at 85° F and then rapidly cooled to 40° F. The lower right graph on page 9 shows the results of grading the berries after a week at 40° F. A very rapid reduction in the amount of marketable fruit resulted from holding the fruit at 85° F before cooling.

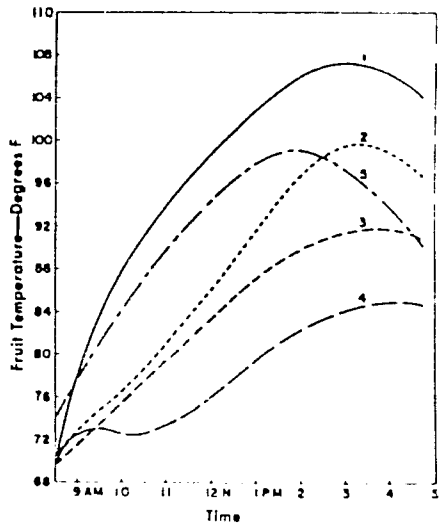
Pickup and loading is done close to the pickers and with as little delay as possible. Note the inverted crates used for shading stacks on the ground.



Tests with Shasta Strawberries advise:

KEEP STRAWBERRIES COOL AFTER PICKING!

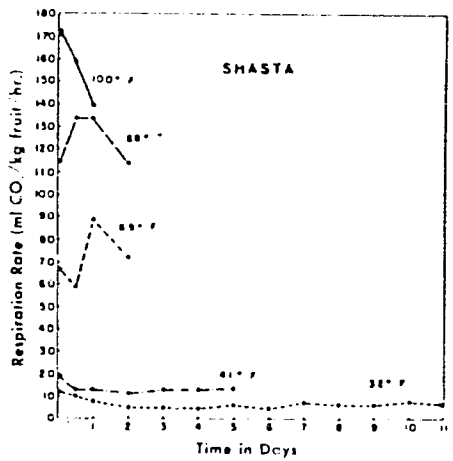
Shade crates in the field



1—Fruit, top of basket in sun; 2—Fruit, bottom of basket in sun; 3—Fruit, top of covered basket; 4—Fruit, bottom of covered basket; 5—Air, in sun.

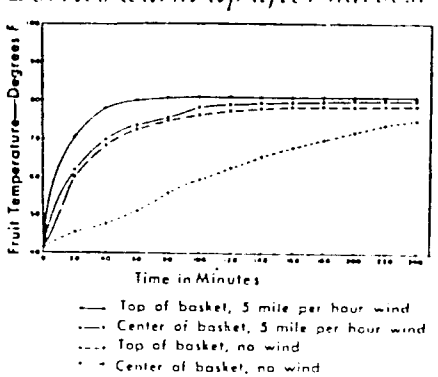
Simulated tests show that berries crated in the field should not remain uncovered in the sun.

High temperatures will "kill" berries



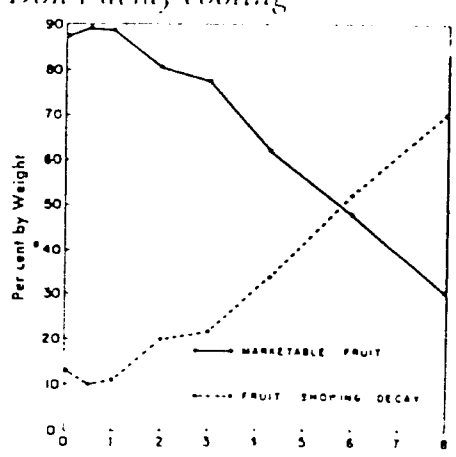
The influence of temperature (32° to 100° F) on respiration rate—which is a measure of the rate of living. The higher the temperature the shorter the life.

Berries warm up after harvest

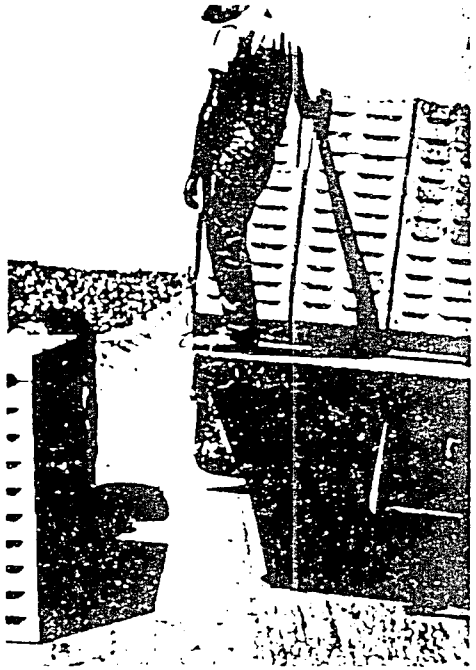


Berries transferred from 41° to 85° F will warm rapidly (regardless of location in basket) in a warm summer breeze. Berries on top of basket will warm rapidly even with no breeze.

Don't delay cooling



Very short delays before cooling to 40° F resulted in sizable losses in marketable berries.



Loading strawberries in field.

SHIPPING

THE SHIPPER and the carrier are responsible for good handling practices as soon at the fruit is under their control. They, too, have to watch out for physical handling and temperature management.

Cooling and Holding

As indicated before, berries should move as quickly as possible from picking to cooling. Rapid cooling will also further decrease the time during which the berries are exposed to higher temperatures. Forced-air cooling, a recent development now in commercial use, appears promising in greatly reducing the time for cooling (Guillou, 1960).

Forced-air cooling is a method whereby the air is forced to pass through the container and around the fruit. By comparison, standard cooling is accomplished by passing the air past the crates or pallets with little air passing through the container. With forced-air cooling, the time required to lower the temperature of the fruit for transit is reduced to one-sixth to one-eighth of the time required under standard cooling conditions. As the upper graph on page 11 shows, in one test a cooling period of 7 to 9 hours was required under standard cooling conditions, while forced-air cooling required less than 1 hour.

To assess the advantages of the handling and cooling procedures of strawberries, a series of trial shipments were conducted. Rapid handling and thorough forced-air cooling were combined as one treatment and compared to fruit handled in the normal manner. In all cases, the fast cooled lots reached 40° F within approximately 1 hour after picking. In contrast, the normally handled fruit required from 8 to 14 hours between picking and the time the fruit reached 40° F. Fruit temperatures at the time of harvest for the various trials ranged from 68° to 84° F. In each case, marketability was increased by the rapid handling of the fruit. The increase ranged from 8 to 21 per cent.

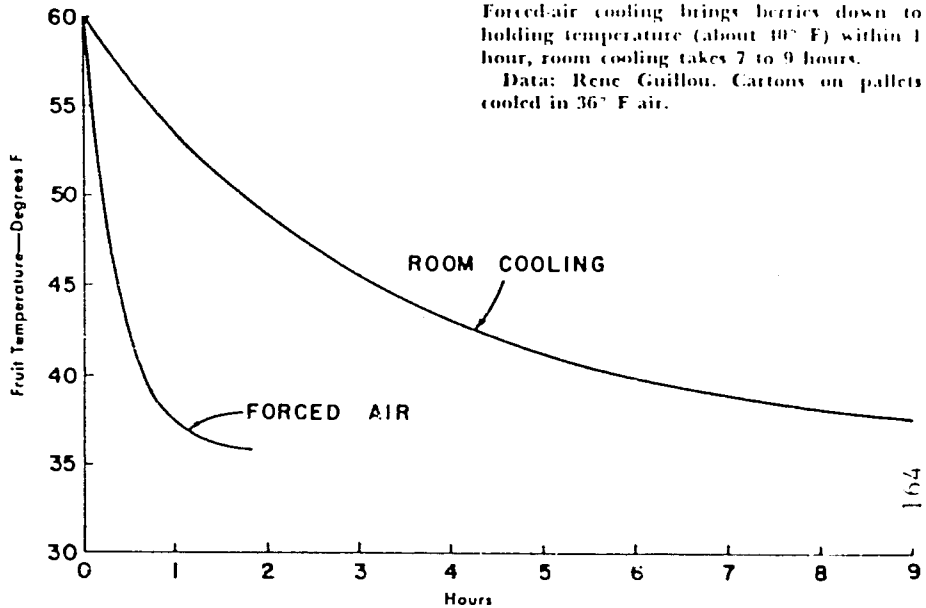
The lower graph on page 11 shows the over-all results of grading following arrival of the fruit in terminal markets. The fast cooled lots had approximately 1 additional day of shelf life at time of arrival, and their rate of deterioration following arrival was slightly slower than the rate of deterioration of the normally cooled lots (Mitchell *et al.*, 1961). This shows a real advantage in terms of increased marketable fruit resulting from good management during handling and cooling of strawberries.

Because they are extremely perishable, strawberries should be marketed as rapidly as possible after harvest. This is particularly important for fruit destined for eastern markets where the

Forced-air speeds cooling

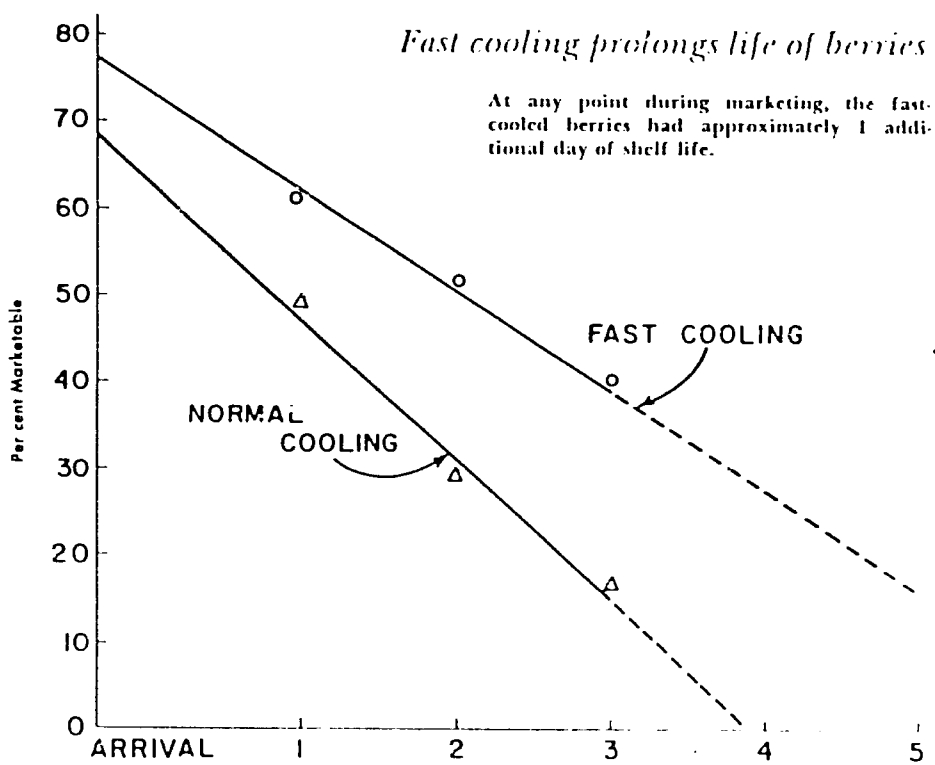
Forced-air cooling brings berries down to holding temperature (about 40° F) within 1 hour, room cooling takes 7 to 9 hours.

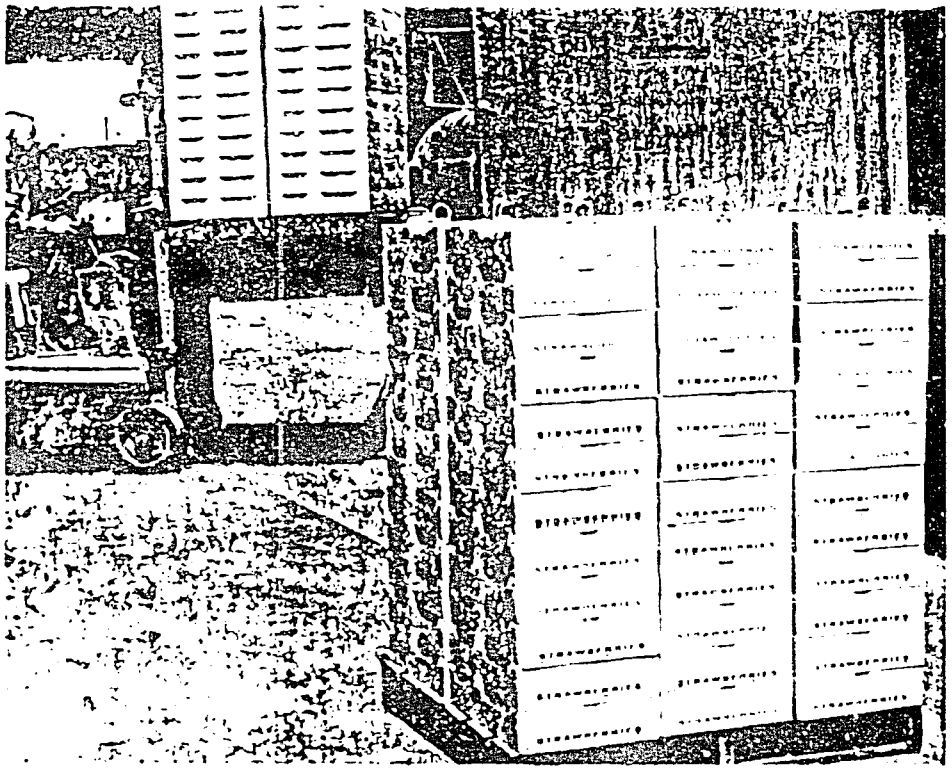
Data: Rene Guillou. Cartons on pallets cooled in 36° F air.



Fast cooling prolongs life of berries

At any point during marketing, the fast-cooled berries had approximately 1 additional day of shelf life.





On arrival at the cooling plant pallets are used to transfer fruit from the truck to the cooler. This reduces handling delay and damage.

transit period may take as long as one week. If holding is necessary, keep the time as short as orderly marketing allows.

During such holding periods, maintain the temperature of the fruit at 32° F. It may be difficult to maintain the desired low temperature of storage fruit if warm fruit is introduced into the same room. If you use forced air cooling, you can pass the cold air across the storage fruit before it passes through the warm fruit. If constant in and out traffic is necessary in a room in which cold fruit is being held, you may consider the use of air "curtains." This directed flow of air across the door opening reduces the mixing of the cold and warm air on either side.

Loading and Transportation

The loading of berries for transport to market must receive the same care as all other steps in the marketing process. The personnel has to be adequately trained and supervised to avoid rough handling of the berries. Warming of the fruit during loading must be prevented since it may cause fruit sweating and will necessitate additional cooling to remove any absorbed heat. The carrier vehicle should be pre-iced and cooled before loading starts. The cold room should be located close to the loading docks and fruit moved directly from storage to rail car or truck. If possible, protective loading curtains or tunnels between

these points should be provided to reduce heat leakage.

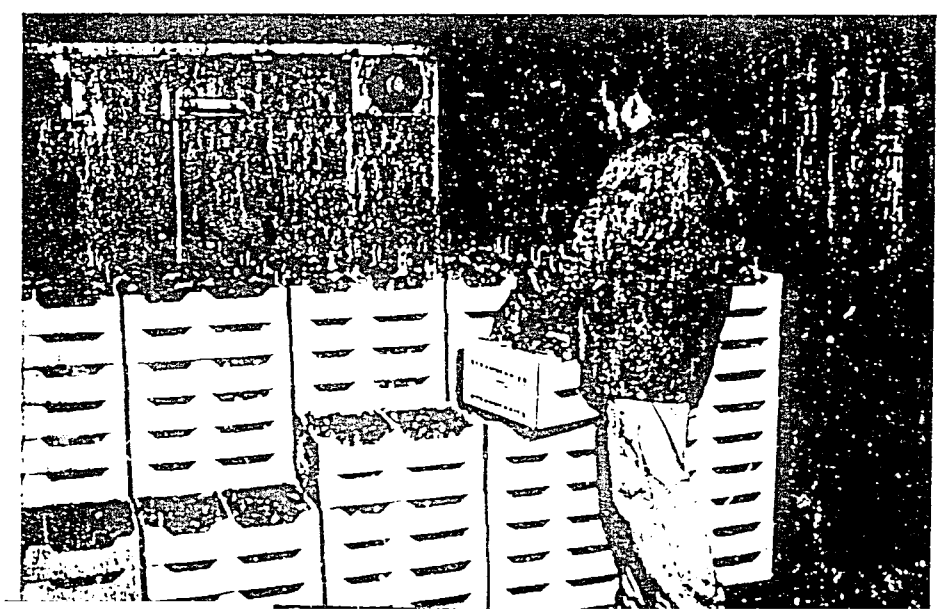
While the main cooling is accomplished by water ice, it is common practice to place approximately 1,000 pounds of dry ice in a paper-lined crib atop the center brace of the car. This is done just before closing the doors on a rail car after loading (Allen *et al.*, 1944; Ryall, 1956*a* and *b*). Studies have indicated that the closest point of the crib should be at least 8 inches from the berries to avoid freezing of the fruit. The paper wraps on most of the cakes of dry ice are left intact to lengthen the effectiveness of the treatment. Sometimes, an additional 200 pounds are broken up and "salted" into the ice bunkers.

The primary purpose of the dry-ice treatment is to build up the carbon dioxide concentration of the atmosphere within the car. Several studies have shown that a carbon dioxide concentration of 10 to 20 per cent is beneficial for the strawberries: it slows their respiration and the growth of decay organisms so that the fruit may arrive in market firmer, brighter and with less decay than nontreated berries.

Studies on the effectiveness of this dry-ice treatment have indicated that an initial concentration of 10 to 20 per cent carbon dioxide is reached within three to four hours, and that the possibility of maintaining a satisfactory concentration depends on the tightness of the equipment. The dry ice which is salted into the ice bunkers helps to build the initial concentration.

As soon as the fruit is properly loaded and the dry ice is in place, the car doors should be closed and remain closed until arrival. The car fans should be started and run continuously until rail transit begins. In mechanical refrigerator cars, trucks, or cars equipped with a supplemental

Correct method of loading strawberries in refrigerated car. Crates are stacked so that wire support (seen sticking out on top of the load) reinforces the stacks. The strong ends of the containers parallel the direction of car movement, thus reducing possible damage to the containers.



Dry ice is used to increase carbon dioxide in the car atmosphere thus reducing spoilage and delaying ripening during transit. Paper is wrapped around most of the cakes to make the carbon dioxide last longer. Note the covers on the first three tiers next to the brace to help protect fruit against freezing.

power supply the fans should be run thermostatically until unloading.

The standard procedure in shipping strawberries by rail is to fill the ice bunkers with ice and add 2 or 3 per cent salt prior to loading, to replenish ice and salt after loading, and to re-ice enroute at designated icing stations (Ryall, 1956*a*). The requirements for icing and salting will vary with the outside temperature enroute — a higher percentage of salt and more frequent re-icings are to be used during hottest weather. The dry ice adds some refrigeration, and the amount of salt required to maintain the desired temperature may be reduced with dry ice.

While it is desirable to keep strawberries near 32° F to hold down decay growth and fruit respiration, care must be taken to prevent freezing the fruit. The freezing point for strawberries has been reported as approximately 30° F. This will vary with variety, growing conditions, and ripeness of the fruit. Because of constantly changing climatic conditions during the season and differences in available equipment, the shipper must become experienced in designating the icing procedure for strawberries. The many variables make it difficult to make a standard recommendation regarding the percentage of salt or re-icing schedule.

TERMINAL MARKET HANDLING

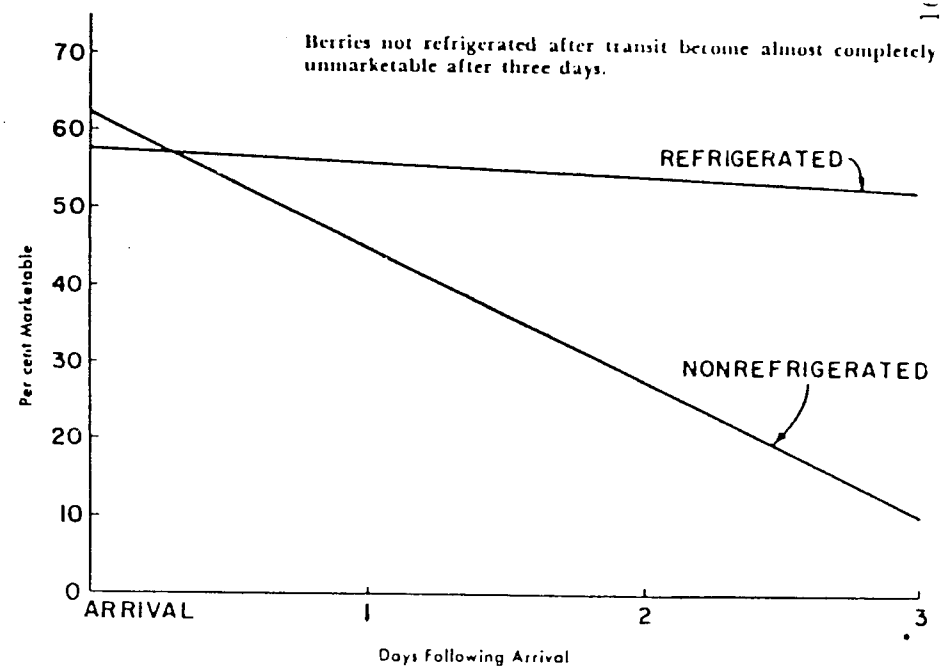
The problems of handling strawberries during wholesale and retail are similar to those during other stages of marketing (Mitchell and Jaxie, 1962). Here, too, deterioration can come from three sources—injuries, self-destruction, and decay. Terminal market handling must try to keep these three sources down.

Rough handling cannot be tolerated at any step in the market process, and becomes even more critical at the marketing phase. As the berries move through the distribution channels they become older, riper, softer, more delicate, and more subject to handling damage. Thus, good training and supervision are needed to prevent rough handling.

Temperature management remains important at this stage of marketing. This is the only practical means of holding self-destruction and decay losses to a minimum. Under commercial conditions, berries are often exposed to relatively high temperatures during unloading and handling in the warehouse and during transit to the retail store. The effect of such conditions on the warming of the fruit was shown earlier in the left bottom graph on page 9.

This warming has a similar result as that of delays in the field before cooling. A test was made to determine the importance of temperature at wholesale and retail levels. No one questioned that the nonrefrigerated berries would deteriorate more rapidly, but the difference in rate was startling. As shown in the graph on this page, about 50 per cent of the re-

Refrigeration during marketing saves fruit



frigerated fruit was still marketable after three days while the nonrefrigerated fruit was almost completely destroyed during this period.

For proper temperature management in the terminal market:

- Refrigerate at all times at 40° F or below; if fruit must be held longer than one day, reduce the temperature to 32° F.
- Avoid unnecessary delays which keep fruit out of refrigeration.
- Provide refrigeration in transit from receiving warehouse to retail store.
- Use refrigerated display if possible; if this is not possible avoid displaying more than a few hours' supply at any time.
- If the berries become warmed, cool them as rapidly as possible by good positioning in the cold room.

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The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks

By
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Alley E. Watada
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remove field debris before storage. A minimum of handling both before and after storage will reduce spoilage. Studies have shown that screening and impact bruising predispose cranberries to physiological breakdown or postharvest softening (*289, 587, 701*).

Cleaned and sorted cranberries can safely be stored in crates or in ventilated consumer units (cartons or film bags) for 2 to 3 weeks at 0°C or 6 weeks at 4° (*414, 762*). Longer storage at 0° may bring on physiological breakdown or chilling injury. Berries in this condition have red-pigmented rubbery-textured flesh rather than the normal crisp, white flesh and have less natural skin luster. Such berries closely resemble those that have been either frozen, smothered, or seriously bruised (*367, 408, 507, 587*). Recent research has shown that warming cranberries stored at 0° to 21° for 1 day each month can help avoid some chilling injury (*408*).

Smothering injury may develop in cranberries stored under poorly ventilated conditions. It is caused by holding berries in tight containers or in overloaded storage spaces where carbon dioxide accumulates and oxygen is depleted. Berries held too long under water may also be smothered. Harvested berries immersed in a flooded bog for 8 to 12 hours or more develop more physiological breakdown in storage (*146*).

Most of the cranberry crop is now processed into sauce or juice. Fruit intended for processing are screened as rapidly as possible and are utilized or frozen shortly after harvest. Such fruit can be frozen at −18°C until needed without quality loss. Freezing berries enhances development of the desired color in the juice. A Wisconsin study (*934*) showed for up to 10 weeks, that refrigerated storage at 4°C is effective in preserving cranberries that are to be processed.

Controlled or modified atmospheres have not been effective in extending the storage life of fresh cranberries beyond that possible with conventional cold storage (*40*). Storage in cartons with sealed polyethylene liners has increased the extent of decay and breakdown at 3°C (*40*).

Further information is available on handling (*241*), precooling (*461*), and market diseases (*367, 762*).

Currants, Gooseberries, and Elderberries
(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Currants, gooseberries, and elderberries are not stored except briefly or when they must be held for processing. A temperature of −0.5° to 0°C is recommended. Red or white currants and elderberries in good condition can be stored 1 to 2 weeks. Black currants are stored a maximum of 4 weeks (*463*). If necessary, gooseberries can be stored 3 to 4 weeks but with some losses from collapsing berries. Gooseberries stored at the recommended temperature for as long as 3 to 4 weeks should be processed immediately after removal from storage (*861*).

As soon as picked, currants, black currants, and gooseberries should be precooled to a temperature lower than 4°C to reduce damage during transport to market (*463*).

Gooseberries have been damaged by exposure to 12 percent carbon dioxide for 4 weeks at 0° but not by 8 percent carbon dioxide. Storage of hard-green gooseberries for longer periods at 0° in perforated polyethylene bags is possible if some carbon dioxide is allowed to accumulate (*464*).

Raspberries
(Temperature, −0.5° to 0°C (31° to 32°F); relative humidity, 90 to 95 percent)

Fresh raspberries soften and decay rapidly and are not adapted for commercial storage. For maximum life, field heat should be removed immediately after harvest by forced-air precooling to 1°C, and the precooled fruits placed at −0.5° to 0°. This temperature retards ripening and development of gray mold rot, rhizopus rot, and cladosporium rot (*367*) and allows 2 or 3 days of storage prior to marketing (*859, 1048*). Ripening and development of fungal rots are further retarded if raspberries are precooled and transported in an atmosphere containing 20 to 25 percent carbon dioxide through use of dry ice (*859*).

Strawberries
(Temperature, 0°C (32°F); relative humidity, 90 to 95 percent)

Fresh strawberries are highly perishable and cannot be stored except briefly. For maximum life, perhaps of 5 to 7 days, fruit should be precooled immediately after harvest and placed at 0°C. The temperature of harvested strawberries in the field can get up to 30°, and higher when exposed to sun; and when fruits are allowed to remain at this temperature for 4 hours, marketability drops by at least 40 percent (*634*). Precooling of whole pallets by forced air is recommended because the desired temperature (1°) can be obtained within 1 hour, whereas air cooling takes 9 hours (*790*). After a few days in storage, the fruit loses some of its fresh bright color, tends to shrivel, and deteriorates in flavor. Deterioration is arrested by low temperature; but after removal from storage, it proceeds more rapidly than in freshly picked strawberries (*755*). The major diseases causing storage losses in strawberries are gray mold rot, rhizopus rot, and leather rot. Prompt precooling to temperatures of 5° or below and holding at such temperatures in transit, storage, and during marketing will minimize such losses (*367, 600, 634, 755, 894*).

Refrigeration is sometimes supplemented with carbon dioxide gas from dry ice to modify the atmosphere during transit or storage. In air transport, pallets are covered with curtain coated fiberboard or heat-shrink polyethylene to retain the high level of carbon dioxide (*366*). High levels of carbon dioxide (10 to 30 percent) slow the respiration rate of the fruit and reduce the activity of decay-causing organisms, thus extending storage and market life (*178, 352, 364, 983*). Carbon diox-

ide atmospheres of 30 percent or greater can cause off-flavor (*365*).

Low-oxygen atmospheres of 0.5 to 2 percent will also reduce respiration rate and decay, but the fruit develop off-flavor (*178*). Postharvest chemical and heat treatments can be useful in reducing decay during storage and handling (*638, 870, 944, 1010*). However, surface sheen can be lost when fruit are dipped in water or solutions.

Cherries

(Temperature, −1° to 0°C (30° to 32°F); relative humidity, 90 to 95 percent)

The approximate time limit for successful handling of fresh **sweet cherries** from harvest to arrival at eastern markets is about 14 days if transit temperatures do not exceed 2°C. The use of sealed polyethylene liners in containers will extend the cold-storage period by at least an additional week. Thus, sweet cherries can be stored in polyethylene at −1° to −0.5° for 2 weeks after harvest and still be shipped by freight to eastern markets. If cherries are held longer than the periods indicated, they lose flavor and brightness. Loss of moisture is one of the most critical factors affecting the fresh appearance of both the fruit and stems. Stems dry out and darken if the humidity is too low. Field containers of cherries should be covered with a tarpaulin or some other moisture barrier from the time of harvest until packaged for shipment. Sweet cherries are very perishable and deteriorate rapidly at nonrefrigerated temperatures. Prompt cooling is essential.

Modified atmospheres obtained with the use of polyethylene liners can lengthen the market life of sweet cherries (*273, 274*). However, these liners must be opened when fruit are removed from cold storage to prevent development of off-flavors at higher temperatures. Controlled atmospheres with 20 to 25 percent carbon dioxide (*700, 702*) or 0.5 to 2 percent oxygen (*151*) can help maintain firmness, green stems, and bright fruit color during storage.

Surface pitting is a major problem affecting the fresh market quality of cherries (*236, 991*). While no cause-and-effect relationship has been found, the severity appears to be affected by mechanical injury. Calcium treatment (*512*) or low-pressure storage (*991*) has been shown to reduce the incidence of surface pitting.

Most sweet cherries are now handled by mechanical equipment for separating the clusters and sizing the fruit, so a postharvest fungicide spray can be applied without an additional handling operation (*717*). See *368* for a discussion of storage diseases of cherries.

Sour cherries are generally unsuitable for storage, except for holding a few days at 0°C to extend the processing period. (See also *251, 622*.)

Coconuts

(Temperature, 0° to 1.5°C (32° to 35°F); relative humidity, 80 to 85 percent)

Coconuts are best stored at 0° to 1.5°C and can be held satisfactorily within that range for 1 to 2 months. Coconuts are subject to mold, weight loss, and drying up of nut milk. They can usually be held about 2 weeks at room temperature without serious loss (*573*). Weight loss is substantially reduced by coating with paraffin wax (*650*) or packaging in polyethylene. Paraffin waxing also is very effective in reducing stress cracking during transport (*132*). Coconuts can become moldy if the relative humidity is too high.

Dates

(Temperature, see text; relative humidity, 75 percent or less)

Dates are subject to two general types of deterioration. One is caused by microbiological activity and includes fermentation by yeasts and molding by fungi. The other form of deterioration is physiological and includes darkening and loss of flavor and aroma. Susceptibility to both types of deterioration increases with increasing moisture content.

Natural, or nonhydrated, dates are somewhat more subject to attack by micro-organisms than steam-hydrated ones because of the partial sterilization accompanying steam hydration. Dates with 23 percent or less moisture are comparatively safe from microbiological spoilage; they become increasingly susceptible as the moisture content exceeds this percentage. Low temperatures also retard microbiological deterioration.

Physiological deterioration of dates is influenced by temperature, moisture content, and type of date. Moisture content is particularly important at higher temperatures. At 24°C, Deglet Noor dates with 20 percent moisture retain color four times as long as those with 24 percent moisture (*795*). Similar relationships occur at cold storage temperatures. A high moisture content gives dates the soft texture many consumers prefer but increases perishability; hence, low temperatures are necessary for successful storage. Dates are not subject to low-temperature injury or freezing injury, so temperatures below 0°C are not harmful.

For best retention of flavor, texture, color, and aroma, Deglet Noor and similar cultivars should be stored at 0°C or lower. They can be held for a year at 0°, somewhat longer at −18°, about 8 months at 5°, 3 months at 15°, and 1 month at 27° (*794*). Dates of the soft, invert-sugar type should be stored at −18° or lower. At temperatures near 0°, they develop sugar spots and darken in a few months. Sugar spots impair the appearance and texture but are harmless. They can be removed by warming, but they will reappear if unfavorable conditions prevail. Soft dates should keep satisfactorily for 1 year at −18° and about 6 months at 0°.

Deglet Noor dates stored in pallet boxes should be packed no more than 60 cm (2 ft) deep and should contain no more than about 22 percent moisture (*797*).

(See also *791, 792, 793, 796, 798, 828*.)

Table 7
Recommended temperature and relative humidity, approximate storage life, highest freezing point, water content, and specific heat of fresh fruits in commercial storage[1]

Commodity	Temperature °C	Temperature °F	Relative humidity (percent)	Approximate storage life	Highest freezing point[1] °C	Highest freezing point[1] °F	Water content (percent)	Specific heat[3] (Btu/lb · °F)
Apples	−1-4	30-40	90-95	1-12 months	−1.5	29.3	84.1	0.87
Apricots	−0.5-0	31-32	90-95	1-3 weeks	−1.0	30.1	85.4	.88
Avocados	[4]4.4-13	40-55	85-90	2-8 weeks	−.3	31.5	76.0	.81
Bananas, green	13-14	56-58	90-95	([5])	−.7	30.6	75.7	.81
Berries								
Blackberries	−0.5-0	31-32	90-95	2-3 days	−.7	30.5	84.8	.88
Blueberries	−0.5-0	31-32	90-95	2 weeks	−1.2	29.7	83.2	.86
Cranberries	2-4	36-40	90-95	2-4 months	−.8	30.4	87.4	.90
Currants	−0.5-0	31-32	90-95	1-4 weeks	−1.0	30.2	84.7	.88
Dewberries	−0.5-0	31-32	90-95	2-3 days	−1.2	29.7	84.5	.88
Elderberries	−0.5-0	31-32	90-95	1-2 weeks	—	—	79.8	.84
Gooseberries	−0.5-0	31-32	90-95	3-4 weeks	−1.0	30.0	88.9	.91
Loganberries	−0.5-0	31-32	90-95	2-3 days	−1.2	29.7	83.0	.86
Raspberries	−0.5-0	31-32	90-95	2-3 days	−1.0	30.0	82.5	.86
Strawberries	0	32	90-95	5-7 days	−.7	30.6	89.9	.92
Carambola	9-10	48-50	85-90	3-4 weeks	—	—	90.4	.92
Cherries, sour	0	32	90-95	3-7 days	−1.7	29.0	83.7	.87
Cherries, sweet	−1 to −0.5	30-31	90-95	2-3 weeks	−1.8	28.8	80.4	.84
Coconuts	0-1.5	32-35	80-85	1-2 months	−.9	30.4	46.9	.58
Dates	[4]−18 or 0	0 or 32	75	6-12 months[4]	−15.7	3.7	22.5	.38
Figs, fresh	−0.5-0	31-32	85-90	7-10 days	−2.4	27.6	78.0	.82
Grapefruit, Calif. & Ariz.	14-15.5	58-60	85-90	6-8 weeks	—	—	87.5	.90
Grapefruit, Fla. & Texas	10-15	50-60	85-90	6-8 weeks	−1.0	30.0	89.1	.91
Grapes, Vinifera	−1 to −0.5	30-31	90-95	1-6 months[4]	−2.1	28.1	81.6	.85
Grapes, American	−0.5-0	31-32	85	2-8 weeks	−1.2	29.7	81.9	.86
Guavas	5-10	41-50	90	2-3 weeks	—	—	83.0	.86
Kiwifruit	−0.5-0	31-32	90-95	3-5 months	−1.6	29.0	82.0	.86
Lemons	([5])		85-90	1-6 months[4]	−1.4	29.4	87.4	.90
Limes	9-10	48-50	85-90	6-8 weeks	−1.6	29.1	89.3	.91
Loquats	0	32	90	3 weeks	—	—	86.5	.89
Lychees	1.5	35	90-95	3-5 weeks	—	—	81.9	.86
Mangos	[5]13	55	85-90	2-3 weeks	−.9	30.3	81.7	.85
Nectarines	−0.5-0	31-32	90-95	2-4 weeks	−.9	30.4	81.8	.85
Olives, fresh	[4]5-10	41-50	85-90	4-6 weeks[4]	−1.4	29.4	80.0	.84
Oranges, Calif. & Ariz.	3-9	38-48	85-90	3-8 weeks	−1.2	29.7	85.5	.88
Oranges, Fla. & Texas	0-1	32-34	85-90	8-12 weeks	−.7	30.6	86.4	.89
Papayas	7	45	85-90	1-3 weeks	−.9	30.4	88.7	.91
Passion fruit	7-10	45-50	85-90	3-5 weeks	—	—	75.1	.80
Peaches	−0.5-0	31-32	90-95	2-4 weeks	−.9	30.3	89.1	.91
Pears	−1.5 to −0.5	29-31	90-95	2-7 months[4]	−1.5	29.2	83.2	.87
Persimmons, Japanese	−1	30	90	3-4 months	−2.1	28.1	78.2	.83
Pineapples	[5]7-13	45-55	85-90	2-4 weeks[4]	−1.1	30.0	85.3	.88
Plums and prunes	−0.5-0	31-32	90-95	2-5 weeks[4]	−.8	30.5	86.6	.89
Pomegranates	5	41	90-95	2-3 months	−3.0	26.6	82.3	.86
Quinces[1]	−0.5-0	31-32	90	2-3 months	−2.0	28.4	83.8	.87
Tangerines, mandarins, & related citrus fruits	4	40	90-95	2-4 weeks	−1.0	30.1	87.3	.90

[1] Recommended storage temperatures; temperatures for ripening certain fruits given in text.
[2] Data from Whiteman (*1030*).
[3] Specific heat calculated from Siebel's (*838*) formula: S = 0.008 × (percent water in food) + 0.20. In metric units of kJ/kg/°C, S = 0.0335 × (percent water in food) + 0.8374.
[4] See text for maturity and cultivar differences.
[5] See text.

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Economic Information
Report 86

Estimated Costs to Grow Strawberries in the Plant City Area, 1977

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ABSTRACT

A cost analysis for growing strawberries in the Plant City, Florida area in 1977 was completed. Initial investment in land and machinery for a 20 acre farm was estimated at $153,770. Annual fixed costs and variable costs were estimated at $1,247 and $2,269 per acre, respectively. Picking and packing costs were estimated at $1.99 per 12 pint flat. Prices needed to break even ranged from $4.92 to $3.75 per flat for yields of 1200 and 2000 flats per acre, respectively.

Key words: Strawberries, Southwest Florida, budgeting, harvesting, costs, break-even prices.

ESTIMATED COSTS TO GROW STRAWBERRIES IN THE PLANT CITY AREA, 1977

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INTRODUCTION

Estimating strawberry growing and harvesting costs aids both production management and credit planning. Break-even strawberry prices can be determined from yields and growing costs. Comparing records from previous seasons with projected budgets helps plan production practices for the following crop. This paper shows estimated initial investment in equipment and land, as well as annual fixed costs, variable costs, harvesting, and packing costs to grow strawberries on a typical 20 acre Plant City area farm.

INVESTMENT AND FIXED COSTS

Plant City area growers and equipment dealers assisted in determining necessary equipment and initial equipment investment. Table 1 shows that equipment needed cost $83,770 at 1977 prices. The well, pump, and permanent overhead sprinkler irrigation system represent $40,000 of this equipment investment. The 20 acres of land are valued at $70,000.

The total equipment investment cannot be charged against one year's crop. Depreciation is the accounting technique which allocates

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the cost of equipment over the life of the equipment. Straight line depreciation of $8,310 for the equipment is listed in Table 1. Land cannot be depreciated.

Various percentages of average annual equipment investment were used to estimate machinery interest, taxes, insurance and repairs in Table 2. Initial investment less depreciation gives value of equipment at the end of the year ($83,770 - $8,310 = $75,460). Average investment during the first year equals initial investment plus year end value divided by 2 ($\frac{\$83,770 + \$75,460}{2}$ = $79,615). The percentages of average investment to charge for each fixed cost were derived from previous engineering and agricultural record studies (2, 3).

Land taxes and interest on land add $5,380 to the equipment fixed costs of $19,559. Total fixed costs for the 20 acre farm are $24,939 or $1,247 per acre. Each grower should use his own records to estimate fixed costs for his operation.

Table 1.--Estimated land and equipment investment and equipment depreciation costs for strawberry production on a typical Plant City area 20 acre farm, 1977

Item	Cost	Salvage value	Life years	Annual depreciaton
Equipment				
60 HP tractor	$12,000	$1,000	10	$1,100
25 HP tractor[a]	7,500	700	10	680
Fumigation rig[b]	870	80	10	79
Sprayer	2,000	150	10	185
Rotovator	2,450	200	10	225
Planting & harvesting aid	750	50	10	70
Portable packing shed	700	0	10	70
1/2 ton truck	7,000	500	8	813
2 ton truck	10,500	1,000	8	1,188
Irrigation system	40,000	1,000	10	3,900
Total equipment	$83,770	$4,680		$8,310
Land 20 A @ $3,500/A	$70,000	Non-depreciable		
Total land and equipment	$153,770	$4,680		$8,310

[a]Includes fertilizer spreader and cultivator

[b]Includes bed press and plastic layer

Table 2.--Estimated fixed costs for land and equipment for strawberry production on a typical Plant City area 20 acre farm, 1977

Item	Cost
Machinery fixed costs	
Depreciation (Table 1)	$ 8,310
Interest[a]	6,767
Taxes, 1.2% of average investment	955
Insurance, 0.3% of average investment	239
Repairs, 3.0% of average investment	2,388
Truck tag and insurance	900
Total machinery fixed costs (20 acres)	$19,559
Land fixed costs	
Interest, 7% of investment	4,900
Taxes, $24/acre	480
Total land fixed costs	$ 5,380
Total fixed costs (20 acres)	$24,939
Fixed cost per acre	$ 1,247

[a]8.5% of average first year machinery investment, average investment = $\frac{\$83,770 + (83,770 - 8,310)}{2}$ or $79,615.

VARIABLE COSTS

Variable costs are tied to growing practices. Prescribed strawberry production practices were determined with the help of Plant City area growers, grower supply dealers, and University of Florida, Institute of Food and Agricultural Sciences publications (4, 5, 6). Estimated time and amount of material, fuel, oil, and labor needed per acre for each production practice are shown in Table 3. For example, rotovating for the cover crop requires the rotovator, a tractor, and a driver. This operation takes 1 1/2 hours per acre. The $6.52 hourly charge covers the driver's time at $3.25 per hour, plus benefits, fuel, oil, and other lubricants on the equipment (7).

Plants and spray materials cost more than one-half of the $2,269 per acre total cash growing costs in Table 3. Plant costs varied depending on cultivar. Tioga was the most common cultivar in the 1976-77 season, while Tufts will likely be most common in 1977-78. Pesticide costs vary depending on spray frequency, weather conditions, and pest pressure. Table 4 shows a sample spray program.

Table 3.--Estimated variable strawberry growing costs per acre for a typical Plant City area 20 acre farm, 1977

Item	Cost
I. Cash costs	
Remove plastic from previous crop	
8 hrs. labor @ $2.66/hr	$ 21.28
Rotovate, 1 time, 1.5 hrs.	
tractor, driver, and rotovator @ $6.52/hr.	9.78
Fertilizer for cover crop	
chicken manure, 3 tons, delivered and spread	45.00
Plant cover crop, 1 time, 1/2 hr. @ $5.28/hr.	2.64
seed, 50 lbs. sorghum @ $0.30/lb.	15.00
Rotovate cover crop, 2 times, 1.5 hrs. each time	
tractor, driver, and rotovator @ $6.52/hr.	19.56
Lay off rows, 1 time, 1 hr. tractor and	
driver, @ $5.28/hr.	5.28
Make beds, 1 time, 1 hr. tractor	
and driver, $5.28/hr.	5.28
Fertilize, 2 times, 1 hr. each time	
tractor, with spreader and driver @ $5.28/hr.	10.56
Fertilizer, 3000 lbs. 6-8-8 @ $152/T	228.00
Lime, 1 ton every 3 years @ $14/T	4.67
Fumigate, 1 time, 4 hrs.	
tractor with fumigator and driver @ $5.97/hr.	23.88
3 helpers @ $2.66/hr.	31.92
Fumigant, 175 lbs. @ $0.80 lb.	140.00
Plastic, 11,000 ft. x 44 in. @ $14/1000 ft.	154.00
Set plants	
40 hrs. labor @ $2.66/hr.	106.40
23,000 plants @ $32/1000	736.00
Cultivate, 3 times, 1 hr. each time	
tractor, with cultivator and driver @ $5.28/hr.	15.84
Spray, 36 sprays, 1/2 hr. each time	
tractor, driver and sprayer @ $5.95/hr.	107.10
spray materials (See Table 4)	429.58
Electricity for irrigation	50.00
Interest on above expenses, 8.5% for 7 months	107.19
Total variable costs	$2,268.96
II. Fixed costs (Table 2)	$1,247.00
III. Total production costs other than harvesting & packing	$3,515.96

An irrigation cost of $50 per acre is listed in Table 3. Irrigation cost ranged from about $30 to $85 per acre. The variation was due primarily to soil type and amount of frost protection required. Soils in low lying areas or those with a spodic horizon require little irrigation after plants are established. Deep sands with low organic matter content require frequent irrigation.

HARVESTING AND PACKING COSTS

Labor costs, including benefits, for fruit harvest were $1.14 per flat. Containers cost $0.55 per flat, while packing shed operations and supervision added another $0.20 per flat. Some growers paid a picking bonus to maintain quality and minimize buyer rejections. Table 5 shows total harvesting and packing costs of $1.99 per flat.

ESTIMATING BREAK-EVEN PRICES

The price growers need to cover costs depends on yield and total costs. The break-even price to cover fixed costs only is calculated by dividing fixed cost per acre by expected yield. For example, if 1400 flats per acre is the expected yield, fixed cost per flat is $\frac{\$1,247}{1400} = \$0.89$ per flat.

The break-even price to cover variable costs only is calculated by dividing variable cost per acre by expected yield. Again using 1400 flats per acre, variable cost per flat is $\frac{\$2,268.96}{1400} = \$1.62$.

Adding fixed, variable, harvesting, and packing costs for the expected yield gives break-even price to cover these items or total costs. For example, at a yield of 1400 flats, break-even price to cover total cost is $0.89 + 1.62 + 1.99 = $4.50.

Break-even prices for 5 yields are shown in Table 6. These prices assume no berries are rejected by the buyer. If some berries are rejected, costs will rise proportionally. As yield increases, the price required to cover total costs decreases.

Table 4.--Rates and costs per acre for a sample strawberry pest control program, 1977[a]

Material	Rate/A	Price	No. sprays	Seasonal cost/A
Captan	6 lb.	$ 0.455/lb.	36	$ 98.28
Benlate	1 lb.	7.30/lb.	16	116.80
Dibrom	1 pt.	4.50/pt.	12	54.00
Plictran	2 lb.	12.00/lb.	6	144.00
Phosdrin 4-E	1 pt.	2.75/pt.	6	16.50
Total				$429.58

[a]The use of trade names in this publication is solely for the purpose of providing specific information. It is not a guarantee or warranty of the products named and does not signify that they are approved to the exclusion of others of suitable composition. A preventive maintenance fungicide spray program will likely be used. The insecticides and miticides included above may not be used if pests are not observed

Table 5.--Strawberry harvesting and packing costs for a typical Plant City area 20 acre farm, 1977

Item	Cost per flat
Picking labor	$1.00
Labor benefits	.14
Containers	.55
Packing shed labor[a]	.10
Labor bonus	.10
Supervision	.10
Total picking and packing cost	$1.99

[a]Level flats, sort fruit, etc.

Figure 1 graphically shows the break-even prices or costs per fla listed in Table 6. Harvesting and packing costs are constant at $1.99 per flat regardless of yield. Other costs per flat decrease as yield increases. The fixed, variable, harvesting, and packing cost curve represents the price growers need to cover total costs at various yields

Fixed, variable, harvesting, and packing costs are compared with 1977 season average yield and price in Figure 2. Point A represents the season average yield of 1,415 flats per acre and season average price of $4.01 per flat (1). Point B represents the price ($4.49) a grower needed to cover all costs at the average yield. The $0.48

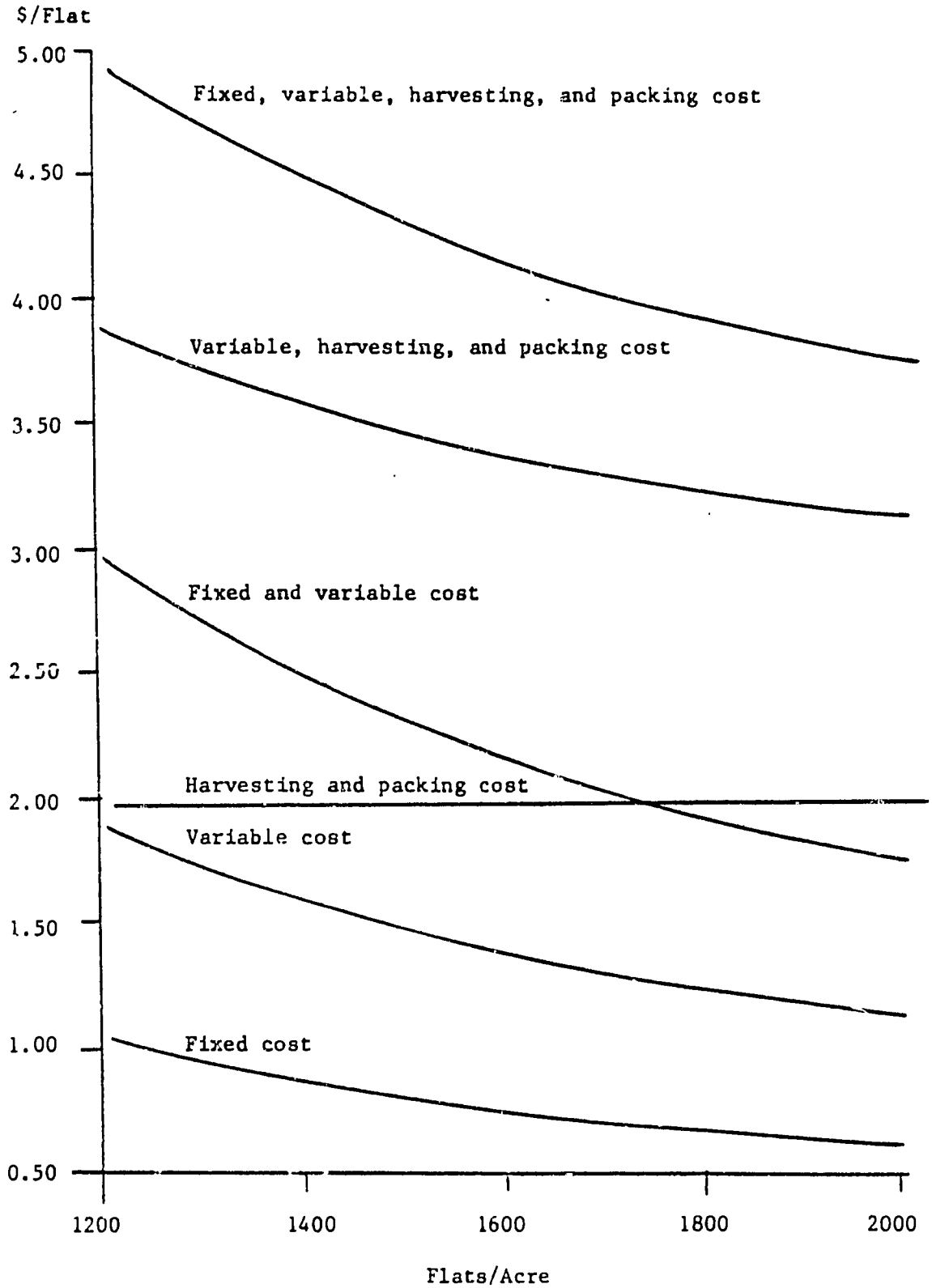

Figure 1.--Estimated break-even prices to cover fixed, variable, harvesting, and packing costs for strawberries, 1977.

difference ($4.49 - 4.01) is a loss on each flat grown. A yield of 1,735 flats per acre was needed to cover all costs at the season average price (Point C).

Table 6.--Estimated break-even prices to cover fixed, variable, harvesting, and packing costs for strawberries, 1977

Yield saleable	Fixed cost	Variable cost	H and P[a] cost	F and V[b] cost	V,H and P cost	F,V,H, and P cost
Flats	$ per flat					
1200	1.04	1.89	1.99	2.93	3.88	4.92
1400	0.89	1.62	1.99	2.51	3.61	4.50
1600	0.78	1.42	1.99	2.20	3.41	4.19
1800	0.69	1.26	1.99	1.95	3.25	3.94
2000	0.62	1.13	1.99	1.75	3.12	3.74

[a]H and P signify harvesting and packing costs, respectively

[b]F and V signify fixed and variable costs, respectively

The January 1977 freeze helped drop yield 49 flats per acre below the 1976 yield of 1,464 flats per acre. Lower quality berries contributed to the 1977 price being $0.32 below the 1976 price of $4.33 per flat.

Figure 2 can aid in planning next year's crop. First, lets assume next year's costs as 1977 costs. A yield and price combination must be above the fixed, variable, harvesting, and packing cost curve for a grower to cover all costs.

The fixed costs must be paid whether the grower grows strawberries or not. Therefore, producing at any yield and price combination falling between the fixed, variable, harvesting, and packing cost curve and the variable, harvesting, and packing cost curve will result in lower losses than if the grower did not produce at all.

Each grower should make his own yield and price projections when planning next year's crop. Furthermore, since prices and cultural practices vary among growers, each individual should analyze his own records, and make his own cost estimates.

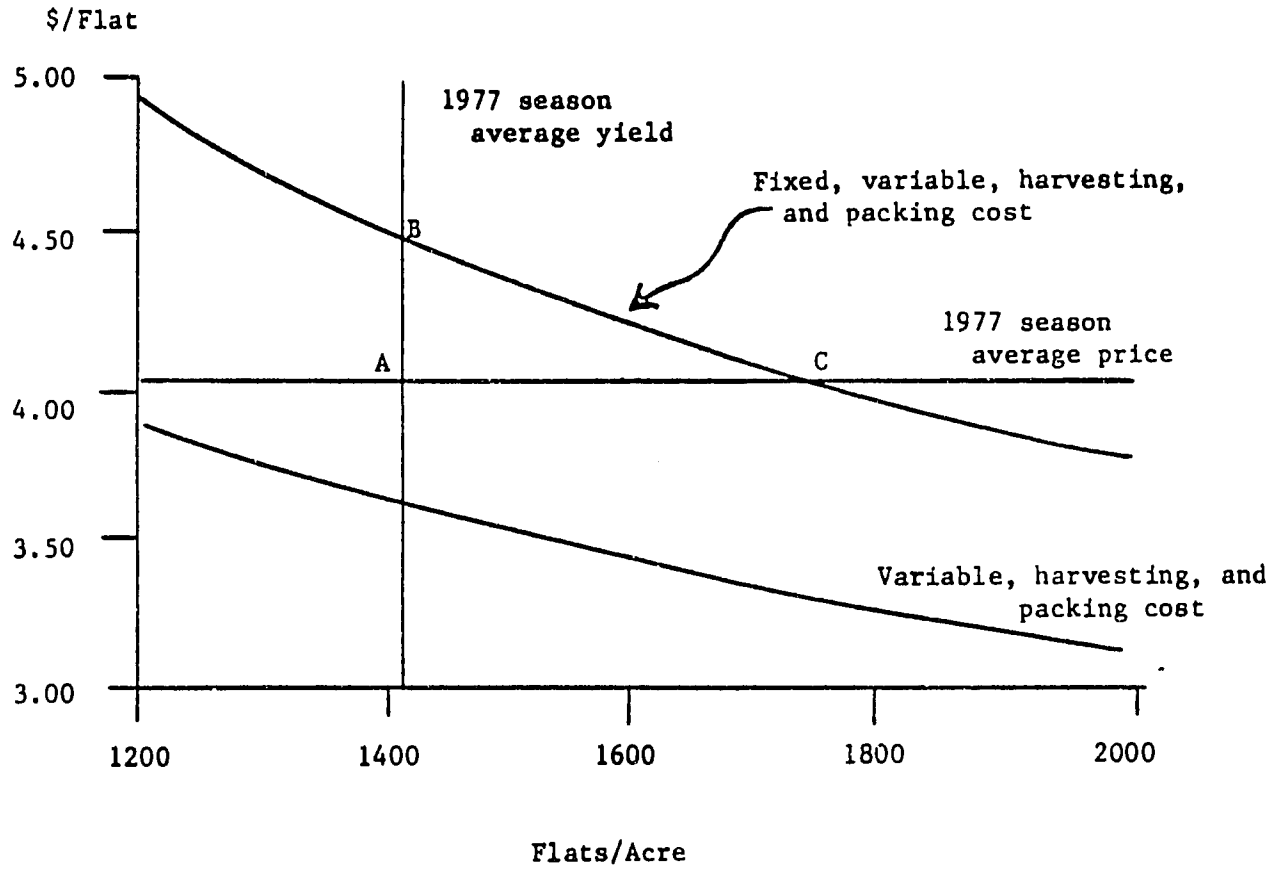

Figure 2.--Comparison of 1977 season average yield and price with break-even prices above fixed, variable, harvesting, and packing costs and variable, harvesting, and packing costs.

"YOU PICK" ECONOMICS

To justify keeping the farm open for "you picks" at the end of the season, the value of "you pick" berries sold must be greater than the costs associated with "you picks".

For example, a grower can keep his 20 acre field open 3 days per week for 3 weeks. During that time 3500 quarts can be sold at $0.25 per quart. Total "you pick" revenue will be $875. However, paying two "you pick" supervisors $3.25 per hour, 10 hours per day, 3 days per week for 3 weeks will cost $585. Return above supervisory labor will be $290 from the field for the 3 weeks.

If spraying continues during "you picking", these costs must also be subtracted. For example, spraying 3 times with captan will cost $17.12. Subtracting $17.12 from $290 leaves a return of $272.88 from "you picks."

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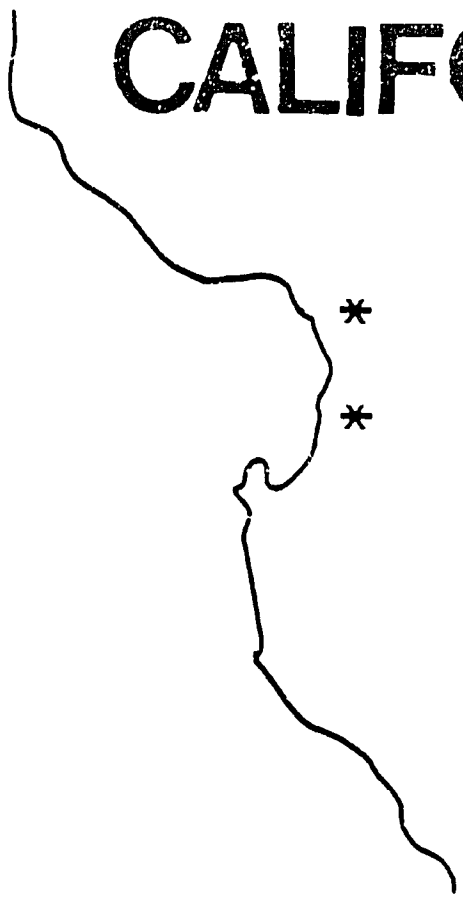
STRAWBERRY PRODUCTION AND COSTS IN THE CENTRAL COAST OF CALIFORNIA



AGRICULTURAL EXTENSION
UNIVERSITY OF CALIFORNIA

1985

STRAWBERRY PRODUCTION
IN THE CENTRAL COAST AREA OF CALIFORNIA

Total strawberry acreage in the Central Coast area has varied from 4,300 to over 4,800 acres in recent years. Favored by cool summers, per acre yield of strawberries in this area is the highest in the world. This is because cool temperatures during the summer help promote flower bud development even under long day conditions. Successful plant breeding programs have developed high quality varieties adapted to this area.

SOIL

Strawberries prefer well drained sandy loam soil, but with good drainage and management high yields of berries can be obtained on other soil types. Strawberry plants are one of the most salt sensitive crops grown in this area. Soil salts should be below 400 ppm. Soils with a high water table cause root rot and plants die out. Soil pH 6 to 7.3 favors best production. Low frost pocket areas should be avoided because of late spring freezes in these locations.

LAND LEVELING

The field should be leveled to a one to two percent slope for drip irrigation. This slope also helps to quickly remove water from winter rains. Irrigation runs should not exceed 150 feet for efficient water use and for picking.

SOIL FUMIGATION

Soil fumigation for disease and weed control is a routine practice by all strawberry growers. Higher berry yields result when the soil is treated with a mixture of methyl bromide and chloropicrin. For maximum results, soils to be fumigated should be low in moisture (not wet), in seedbed tilth, low in organic matter, free of plant residue, free of clods, and above 52°F. Continuous plastic tarps help hold in fumigant and should not be removed for at least 48 hours. Fifteen days or longer should lapse after plastic tarp removal, depending upon soil type, moisture and temperature, before transplanting to insure that no phytotoxic residues remain in the soil.

BED PREPARATION

For summer plantings the beds are listed up on 44 to 52-inch centers. Bed width will depend upon plant spacing, variety and methods of handling labor. Beds 8 inches or higher are desirable, as this helps drainage and soil aeration that prevents root rot and salt buildup. Bed tops should be level and have a uniform slope. Avoid tilted or dips in the beds and furrows as these areas are more susceptible to disease and poor vigor. Extra effort in tractor work making beds and furrows smooth and even will pay big dividends later.

PLANTING

Beds are premoistened by sprinkling. Deep, narrow grooves are then opened in the beds by using a specially constructed disk. Plants are hand-planted into the grooves so the crown is at the soil surface. Planting plants too high or too low result in poor vigor or die out. Grooves are closed by using a special press wheel. Then dirt is settled around root by immediate sprinkling.

SPACING

Various spacings are used by growers. Two rows 14 inches apart with plants 8 to 11 inches apart on a 48 to 52-inch bed are used in many fields. A planting of 4 rows on a 60-inch bed is used in a few winter planted fields. Plant population, depending upon varieties for summer planting, of 18-21,000 per acre is needed for highest yield.

PLANTING DATES

Summer plantings using properly stored plants are: Chandler, Pajaro--August 20 to September 1; Aiko--August 25 to September 5; Selva--September 20 to October 10. Winter planting with mature, recently dug plants: Chandler--November 1 to November 8. Selva for winter plantings should be given 3 weeks of cold storage (34-36°F) before planting.

VARIETIES

Pajaro, Aiko, Chandler and Selva are the main varieites grown in this area. Aiko is a late high yielding variety that starts producing in early May and continues until November. Pajaro produces almost 95% fresh market fruit and on cool summers will produce until late September. If heat spells occur this variety will stop producing before mid-August.

Chandler is a new early variety with a tendency to overgrow by mid-summer. This variety produces very large yields of mixed size, high flavor fruit on summer planting. Selva is a day neutral that produces a very hard berry. It tends to hold it's fruit size throughout the season. This variety is still being market tested and is very susceptible to mites.

IRRIGATION

Immediately following transplanting, the fields should be sprinkled to settle the soil around plant roots. Summer-planted fields will benefit from light sprinkler irrigation every other day for eight or more weeks. Strawberries for top production require frequent, light applications of water low in salts (below 600 ppm). During harvest seasons, irrigate 1-2 times per week. For each acre of strawberries, you will need a minimum of 15 gallons of water per minute for peak water usage periods unless you have a reservoir.

FERTILIZATION

After leveling, most fields are broadcasted with 1-2 tons lime or gypsum. This should be thoroughly incorporated into soil. We do not recommend broadcasting of fertilizer because too often growers light disk or chisel the ground to incorporate these salty chemicals. This practice has resulted in very severe plant damage because as the beds are folded in, these salts are then banded in the center of the bed causing poor vigor and die out. Sidedressing fertilizer into the bed away from roots of summer planted strawberries is the safest way to apply phosphate, potassium and some nitrogen. Some growers will place slow release nitrogen just below root system in the planting slot just before planting; 16-20 plus N-Serve can be used this way if it is not in contact with root system. Manure should not be applied within three months before planting, if at all.

Summer-planted fields should not be fertilized after transplanting with nitrogen until plants are growing actively. Nitrogen needs will vary from 130 to 280 pounds per acre, depending upon the variety and past crop history. Nitrogen, when applied as a sidedressing after planting,

except for the slow release types, should be applied in small amounts of 40 pounds or less per acre at any one time. Some nitrogen will need to be applied in the water during the summer to carry the plants through to the end of harvest. Selva variety will need more nitrogen during harvest period than non-day neutral varieties.

winter-planted fields, nitrogen as 16-20 + N-Serve or slow release ıld be placed in the planting groove using 140-200 lbs. N prior to planting and covered with 1/2-inch of soil to prevent root burn.

PLANT MAINTENANCE

Plants transplanted in the summer will produce runners and some flowers that will need to be cut off to help promote large multiple crown growth. High moisture levels in the soil will be needed during the first 8 to 10 weeks of growth during hot weather. After the plants have been growing for two to three weeks, nitrogen can be applied if field has not been slot fertilized.

PRUNING

Remove only dead or dying leaves, as removal of functional leaves will reduce yield. This is especially true in late plantings, or when the plants are weak. Never prune before very late January.

PLASTIC MULCH

In summer-planted fields, plastic mulch can be laid down in February, unless you have planted late or plants are very weak, then plastic should be laid down in early December. Some larger outer leaves are removed to help reduce labor costs when applying plastic. Winter-planted fields should have the plastic mulch applied as soon as the plants become established to stimulate early growth for development of flower buds in the crowns under short day length conditions. Plastic sheets should cover top and shoulder of beds. This cover will need to be anchored every 8 to 10 feet with a shovel full of dirt or the use of wire, plastic or wooden holders.

HARVEST

Strawberry harvest, depending upon variety and location, may begin in mid-April and continue through most of the summer. Picking carts holding a crate with 12 baskets are pushed through the field by pickers. A crate will hold approximately 11 to 12 pounds of berries. Maturity of berries picked will depend upon how far they are to be shipped and the variety. Selva variety should be picked mostly colored because of its very firm texture and marginal flavor. Processed berries are picked fully ripe with stem and calyx removed and placed in trays without baskets.

DISEASES

Strawberries are attacked by a variety of leaf, fruit, crown and root diseases. For control of diseases, contact your local Farm Advisor for the latest recommendations.

INSECTS

Mites (two-spotted and cyclamen), various worms, aphids, lygus bugs, root weevil and snails can be serious pests of strawberries. Contact your local Farm Advisor for the latest chemical controls.

MANAGING SECOND PRODUCTION YEAR

About 33% of the strawberry plantings are kept for a two harvest season.

CULTIVATION

Strawberry furrows are usually cultivated in early spring to control weeds and to break up the surface compacted layer. Only a very minimum amount of cultivation is needed in established plantings.

FERTILIZATION

Fertilizer placement after the plastic mulch has been applied is limited to irrigation water. Nitrogen so applied follows water movement and can be leached below the root zone. Apply nitrogen before the cold fall weather and in the spring as plants begin to grow; 20 to 30 lbs. of nitrogen per month may be needed in some fields.

PRUNING

Many second year fields are oiled in late January. This helps kill certain overwintering insects and aids leaf removal by killing most of the green leaves. The Aiko variety is sensitive to oil under some conditions and should not be treated. In early February, the plants are pruned by mechanical rotobeater and/or by hand. All but the very small center leaves should be removed from the plants and destroyed as a sanitary measure.

IRRIGATION

Irrigation is the same as first year berries. Salts may build up in some soils. These fields may need to be sprinkler-irrigated in years of low rainfall to leach salts below the root zone in February and March.

PEST CONTROL

Diseases and insects tend to build up more in second year plantings. Care should be taken to start the year with very low populations of mites, root weevil and slugs.

PLASTIC REMOVAL

At the completion of the harvest season, remove the plastic mulch. This material breaks down slowly in soil and causes numerous problems in preparing and managing soils for the next crop.

YIELDS

Chandler and Pajaro are capable of producing 4,500-7,000 trays of fresh market strawberries in the first year of production if grown properly. The Aiko and Selva varieties have the potential of producing 8,000 or more trays of fresh market strawberries in years with normal winter temperatures. Yields of Aiko have been recorded as high as 10,000 trays per acre.

STRAWBERRY SAMPLE COST - 10 acre in production

ESTABLISHMENT COST PER ACRE

August - December 1985-86

	Hours Per Acre			
	Labor Hour	60 h.p. Tractor	30 h.p. Tractor	Cost per Acre
Plow, disk, subsoil, pre-fertilize	7	7		168.84
Survey for leveling, 4 hrs @ 18.00/hr				72.00
Leveling and grading 3X	7	7		168.84
Chisel 3X	3	3		72.36
Sprinkle 1X	2			14.40
Plastic removal-fumigation and disposal				51.74
List beds	2		2	25.76
Sprinkle-preplant 2X	2		1	20.08
Shape beds and open plant furrows	3		3	38.64
Transplant and close plant furrows	38		4	296.32
Bed and furrow maintenance	3		3	38.64
Pest control 5X	5		5	64.40
Irrigate-sprinkle 8X and pipe removal	15		5	136.40
Cut runners 3X and blossom weed 2X	49			352.80
Fertilize 1X	2		2	25.76
Replant (5% stand)	6			43.20
Total Cultural Labor and Field Power	143	16	26	$1,590.18
Materials:				
Water 8X				22.00
Fumigation contract				1200.00
Preplant fertilizer				200.00
Plants (plus fungicide) 19,950 @ 29.58/1000 plus 5% replant				622.12
Fertilizer slow release				320.00
Pest control 5X				167.00
Drip system - 5 year drip filter pipes - $100/year + drip line 1800 ft. - 48" bed 18c/ft				424.00
Rent - 1 crop every 2 years - $400.00/year				800.00
Total Material Cost				$3,755.12
Total Cultural Labor, Field Power, and Materials Costs				$5,345.30
General Expenses: office, phone, insurance - estimate 10% of above				530.87
Trucks				172.00
Repairs				63.40
Total Cash Overhead				766.27
Interest on Working Capital (average of 10%)				743.73
TOTAL CASH COST				$6,855.30

Investment	Per Acre	Depreciation	Interest 14% on 1/2 Cost	
Building	160.00	16.00	11.20	
Irrigation-sprinkler	884.00	88.40	61.88	
Power equipment	2600.00	260.00	182.00	
Total Investment and Interest		364.40	255.08	619.48
TOTAL COST TO ESTABLISH STAND				$7,474.78

Labor costs, including fringe benefits and bookkeeping are figured at the following hourly rate: Labor $7.20. Cash costs of fuel, oil, repairs for 60 h.p. diesel crawler $16.92 per hour, 30 h.p. wheel tractor $5.68 per hour.

STRAWBERRY SAMPLE COST PER ACRE

FIRST YEAR FRUIT HARVEST

	Labor Hour	Hours Per Acre 30 h.p. Tractor	Sprayer	Cost per Acre
Pruning and weeding	38			273.60
Plastic mulch	24	4		195.52
Pull plants through plastic 2X and weed	15			108.00
Irrigate 38X and repair drip system	38			273.60
Weed and runner cut 3X	34			244.80
Pest control 10X	10	10	10	177.50
Miscellaneous	10	2		83.36
Total Cultural Labor and Field Power	221	12	10	$1,356.38
Plastic mulch				135.00
Pest control 10X				482.00
Water - 2.5 acre feet at $22/acre foot				55.00
Total Material Cost to Harvest				$ 672.00
Total Labor, Field Power and Materials				$2,028.38
General Expenses: office, insurance, tax, etc., estimate 12% of above				289.39
Trucks				264.00
Repairs				159.80
Total Cash Overhead Costs				$ 713.19
Interest on Working Capital (average of 10%)				292.47
Subtotal Cultural Cost Except Harvest				$3,034.04
TOTAL CULTURAL COST EXCEPT HARVEST				$10,508.82

Harvest Cost: Pick and supervision - estimate $1.70 per tray; crates, baskets, wires .83 = 2.53 total harvesting tray cost.

YIELD VS. COST

Trays Per Acre	Cultural cost per tray	Total cost per tray
4000	2.62	5.14
5000	2.09	4.62
6000	1.74	4.27
7000	1.50	4.02

STRAWBERRY SAMPLE COST - 10 Acre Production - Processing
SECOND-YEAR FRUIT HARVEST - Oct-July

	Hours Per Acre Labor Hour	Sprayer	30 h.p. Tractor	Cost per Acre
Prune and leaf removal	24		2	184.16
Cultivate and repair roads	2		2	25.76
Fertilize 1X	1		1	12.88
Weed and runner cut	34			244.30
Irrigate 25X	26			187.20
Pest Control 10X	10		10	128.30
Removal old plastic and pipes	9		1	70.48
Disk 2X	2		2	25.76
Total Cultural Labor and Field Power	108	10	18	$ 879.84
Fertilizer				268.00
Water 2-acre feet				44.00
Pest Control				400.00
Total Material Cost to Harvest				712.00
Total Labor, Field Power and Materials				$1,591.84
General Expense - 10% of above				164.05
Repair				143.60
Truck				172.00
Rent - 2 crops every 3 years $400/year				600.00
Total Cash Overhead Costs				$1,079.65
Total Cash Costs				$2,671.49
Interest On Working Capital (average of 10%)				263.00

Investment	Per Acre	Depreciation	Interest 14% on 1/2 Cost	
Buildings	160.00	16.00	11.20	
Irrigation equipment	884.00	88.40	61.88	
Power equipment	2600.00	260.00	182.00	
Total Investment and Interest		364.40	255.08	$ 619.48
TOTAL CULTURAL COST - 2 years				$3,553.97

Harvest Cost - Labor - Supervision - Bookkeeping - hourly. 18c/lb includes dockage

Labor costs, including fringe benefits and bookkeeping are figured at the following hourly rate: Labor $7.20. Cash costs of fuel, oil, repairs for 60 h.p. diesel crawler $16.92 per hour, 30 h.p. wheel tractor $5.68 per hour and sprayer at $4.87 per hour.

YIELD VS. COST

Pounds/Acre	Total Cost Per Lb.
30,000	.30c
40,000	.27c
50,000	.25c

CooperativeExtension

College of Agriculture
Washington State University
Pullman, Washington

EXTENSION BULLETIN 1077
NOVEMBER 1982

1982 Strawberry Enterprise Budget, Western Washington

Richard W. Parker, William P. A. Schrier, Craig McConnell

Farm Business Management Reports

EB 1077

1982 STRAWBERRY ENTERPRISE BUDGET FOR WESTERN WASHINGTON

Richard W. Carkner, William P.A. Scheer, and Craig MacConnell*/

INTRODUCTION

This publication presents estimated 1982 costs and returns for establishing and producing strawberries in western Washington. This information will be helpful to producers, lenders, and others interested in making better farm management decisions, including profit planning, financing, marketing and resolving numerous related farm business-management problems.

It is recommended that individual growers use the blank spaces provided to adjust the budget tables to their individual farm circumstances. Also, local Cooperative Extension Agents and fieldmen should be consulted for recommendations on field operations and operating inputs.

SOURCES OF INFORMATION

Personal interviews of selected area producers served as the basis for identifying field operations and machinery complements commonly used. These producers are considered to be representative of well-managed farms. Quantities and types of materials (for example: plants, fertilizer, herbicides, and insecticides) used in these budgets are based on recommended practices. Several western Washington suppliers were contacted to obtain current prices for machinery, equipment, custom operations, fertilizer, chemicals, and fuel. Farmers wishing to substitute costs for their own machinery may find EB 1055 "Costs of Owning and Operating Farm Machinery in Washington," useful in making cost estimates.

BUDGET ASSUMPTIONS

The following assumptions were used in the budget development:

1. A ten-acre farm is totally devoted to strawberry production.

2. Supplemental hand-set irrigation is used.

3. The crop is established one year and in full production the following year. The costs of establishment are allocated over three productive years.

4. Expected average annual yield is ten thousand pounds per acre.

5. Six thousand pounds of strawberries are sold directly to processors. The remaining four thousand pounds are direct-marketed by the producer.

6. New purchase prices are used for all machinery and equipment with the exception of a light truck. This assumption may overstate current production costs, but it provides an indication of the strawberry enterprise's ability

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to replace machinery and equipment. Continuing machinery and equipment price increases mean that the depreciation claimed on previously purchased equipment understates the capital required to replace these assets. Current pricing of assets gives an indication of an enterprise's long-run ability to replace depreciable assets.

DISCUSSION OF BUDGET INFORMATION

The strawberry enterprise information is presented in two separate budgets; one for the establishment year, and one for subsequent production years. Activities in the establishment year include land preparation, planting and other development activities. Activities in the second year include annual production activities, as well as harvesting. The strawberry budgets are presented in several tables and each will be discussed below.

Schedule of Operations and Selected Costs For Establishment and Full Production - Tables 1 and 1A

These tables outline the schedule of field operations by calendar month, the type of machine used, and the number of times used per acre. The costs of field operations are divided into two categories. The first is the cost of machinery ownership, or fixed costs. The second category, variable costs, is associated with operating machinery, hiring labor, and purchasing services and materials. Total cost is the sum of machinery fixed and all variable costs.

Machinery fixed costs include depreciation and interest on investment, taxes, and insurance. These costs do not vary with the crops produced, given the ownership of a specific machinery complement, and are incurred whether or not a crop is grown. Machinery fixed costs for a specific field operation are estimated by multiplying the machinery hours per acre times the per hour cost.

Variable costs vary directly with the crop grown and the number of units or acres produced. Variable costs include fuel, oil and repairs, and all the inputs such as fertilizer, chemicals, and custom work. Machine operating labor is also included in variable costs.

Note that the table titles indicate "selected" costs. The tables do not include the following variable costs shown in Tables 2 and 2A: interest on operating capital, variable overhead, and variable irrigation costs. The following fixed costs are also not included here: land rent, management charge and irrigation fixed costs.

Summary of Production Costs Per Acre for Establishment and Full Production - Tables 2 and 2A

Tables 2 and 2A summarize variable and fixed production costs, and for full production estimate breakeven prices necessary to cover variable and total costs. The land charge under fixed costs is based on an estimate of cash rent.

Breakeven prices are estimated by dividing costs by units of production. Total production, or yield per acre, is shown in Table 3. Breakeven prices to cover variable costs are calculated by dividing variable costs by units of production. The result is the minimum product price necessary to cover all out-of-pocket costs identified in the budget. When total costs are divided by units of production, the result is the minimum price necessary to cover all production costs including machinery, operator labor, and land charges.

Summary of Receipts, Costs, and Profitablity - Table 3

Table 3 summarizes per acre costs and returns and includes measures of profitability. The first profit measure is returns over variable costs; calculated by subtracting total variable costs from total receipts. A second profit measure, returns to land and management, is calculated by subtracting machinery fixed costs, except land rent, and prorated establishment costs from returns over variable costs.

Monthly Cash and Labor Requirements and Hourly Machinery Costs - Table 4

Table 4 contains some supporting details for the costs outlined in the schedule of operations. Direct cash operating expenses (at the top of the table) include outlays for materials, hired labor including harvesting, fuel and lubrication, and machinery repairs. The right-hand side of the table provides unit prices and quantities for each operating input. Farmers and lenders attempting to estimate monthly operating costs should use the total cost figures at the bottom of this section. Note that machinery labor and interest on operating capital costs are not included. In the lower third of the table, there is a summary of monthly machinery labor requirements.

Establishment Costs

The costs of establishing the strawberry stand must be recovered over its useful life, estimated in this budget to be three years. This is accomplished by amortizing the establishment costs over three years assuming a 12 percent cost of capital. Establishment costs are identified as prorated establishment costs under fixed costs in Table 2A.

Returns Over Total Costs at Various Yields and Prices - Table 5

This table presents returns over total costs identified in Table 2A for ranges of yield and price. The combinations of yield and price that provide positive returns are to the right of the heavy black line, those to the left show returns below production costs. Yield and price combinations falling on the line itself represent breakeven price and yield combinations, i.e., gross returns (yield X price) equal to total costs. Total production costs for each yield level are adjusted for harvest costs.

This information can be used to estimate the impact of yield and/or price changes on returns. It can also be used to estimate yield and price combinations necessary to produce a specified dollar return over total costs. For example, prices of 45 cents or greater combined with yields of 9,000 pounds or greater will generate $150 or more over total costs.

Irrigation

A hand-move irrigation system is included in the strawberry budget. Approximately 4 acre inches of water are applied in July and August. (Appendix Table B).

Both fixed and variable costs are estimated (Table 2A). Fixed costs include depreciation and interest on the irrigation investment. Depreciation is based on an estimated useful life of 15 years and a 25 percent salvage value. Interest is calculated on the average investment value at 12 percent annual interest.

Variable irrigation costs include repairs, electricity (fuel) and labor. Annual repair costs are estimated at 4 percent of the total investment. Electric power costs are based on approximately 2000 KWH at 4 cents per kilowatt.

Machinery Complement

Machinery used in the enterprise is detailed in Appendix Table A. List prices and the hours of use annually are indicated.

STRAWBERRY ESTABLISHMENT COSTS, ESTABLISHMENT YEAR
WESTERN WASHINGTON DATA, 10 ACRE ENTERPRISE - 1982

TABLE 1: SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE

OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	VARIABLE COST: FUEL,OIL, LUBE,AND, REPAIRS	VARIABLE COST: MACH. LABOR	VARIABLE COST: SERVICE	VARIABLE COST: MATERIALS	TOTAL SELECTED VARIABLE COST	TOTAL SELECTED COST
					$	$	$	$	$	$	$
SOILTEST	ANALYSIS	AUG						4.50	0.0	4.50	4.50
NEMATODE TEST	ANALYSIS	AUG						2.50	0.0	2.50	2.50
APPLY HERB	30HP,100 GAL SPRAYER	AUG	0.61	0.74	7.45	0.48	3.34	0.0	62.25	66.08	73.52
PLOW	CUSTOM PLOW	SEPT						25.00	0.0	25.00	25.00
APPLY DOLOMITE	CUSTOM APPLICATION	SEPT						3.50	97.50	101.00	101.00
FUMIGATE	CUSTOM FUMIGATE	SEPT						30.00	297.00	327.00	327.00
PACK	30HP, PACKER (2X)	SEPT	1.83	2.22	28.35	0.44	9.98	0.0	0.0	10.42	38.77
ROTOVATE	30HP, ROTOVATOR	SEPT	2.98	3.60	65.08	1.08	16.21	0.0	0.0	17.28	82.36
DISK	30HP, 6.7' OFFSET DISK	SEPT	0.39	0.47	11.23	0.09	2.13	0.0	0.0	2.22	13.45
ROTOVATE	30HP, ROTOVATOR	MAR	2.98	3.60	65.08	1.08	16.21	0.0	0.0	17.28	82.36
FERTILIZE	30HP, FERTILIZER SPREADER	MAR	0.39	0.48	8.85	0.13	2.14	0.0	47.40	49.67	58.52
PLANT BERRIES	30HP, 2 ROW TRANSPLANTER	APR	1.96	2.38	42.67	0.55	10.70	0.0	440.00	451.25	493.91
PLANT	4 LABORERS (8 HOURS)	APR						36.00	0.0	36.00	36.00
CULTIPACK	30HP,CULTIPACKER	APR	0.54	0.66	13.96	0.13	2.97	0.0	0.0	3.09	17.05
FERTILIZE	30HP, 2 ROW CULT W/FERT ATTACH	MAY	0.95	1.15	16.89	0.36	5.16	0.0	68.10	73.63	90.52
APPLY HERB	30HP, 100 GAL SPRAYER	MAY	2.46	2.97	29.78	1.93	13.37	0.0	15.20	30.50	60.28
REPLANTING	HAND LABOR 1.5 HOURS	MAY						6.75	22.55	29.30	29.30
WEEDING	HAND HOE	JUNE						9.00	0.0	9.00	9.00
APPLY INSECT	30HP, 100 GAL SPRAYER	JUNE	0.61	0.74	7.45	0.48	3.34	0.0	23.10	26.93	34.37
WEEDING	HAND HOE	JULY						9.00	0.0	9.00	9.00
IRRIGATION	LABOR, ELECTRICITY AND REPAIRS	JULY		4.00		21.64		16.00		37.64	37.64
CUT RUNNERS	30HP, 2 ROW CULTIVATOR	AUG	0.95	1.15	16.89	0.36	5.16	0.0	0.0	5.53	22.42
APPLY INSECT	30HP, 100 GAL SPRAYER	AUG	0.61	0.74	7.45	0.48	3.34	0.0	23.10	26.93	34.37
FERTILIZE	30HP, FERTILIZER SPREADER	AUG	1.90	2.29	33.78	0.72	10.33	0.0	59.25	70.30	104.08
IRRIGATION	LABOR, ELECTRICITY AND REPAIRS	AUG		4.00		21.64		16.00		37.64	37.64
WEEDING	HAND HOE	SEPT						9.00	0.0	9.00	9.00
APPLY HERB	30HP, 100 GAL SPRAYER	OCT	2.46	2.97	29.78	1.93	13.37	0.0	33.20	48.50	78.28
TOTAL PER ACRE					384.68	53.53	117.74	167.25	1188.65	1527.17	1911.85

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STRAWBERRY PRODUCTION COSTS - FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON 10 ACRE ENTERPRISE - 1982

TABLE 1A: SCHEDULE OF OPERATIONS AND SELECTED COSTS PER ACRE

OPERATION	TOOLING	MONTH	MACH. HOURS	LABOR HOURS	MACH. FIXED COST	VARIABLE COST: FUEL,OIL, LUBE,AND, REPAIRS	VARIABLE COST: MACH. LABOR	VARIABLE COST: SERVICE	VARIABLE COST: MATERIALS	TOTAL SELECTED VARIABLE COST	TOTAL SELECTED COST
					$	$	$	$	$	$	$
CULTIVATE	30HP, 2 ROW CULTIVATOR	APR	0.95	1.15	12.46	0.47	5.16	0.0	0.0	5.63	18.09
APPLY HERB	30HP, 100 GAL SPRAYER	APR	1.23	1.49	19.69	0.55	6.68	0.0	15.20	22.44	42.13
WEEDING	HAND HOEING (2 HRS)	APR						9.00	0.0	9.00	9.00
SPRAY INSECTS	30HP, 100 GAL SPRAYER	APR	1.23	1.49	19.69	0.55	6.68	0.0	3.00	10.24	29.93
APPLY INS/FUNG	30HP, 100 GAL SPRAYER (2X)	MAY	2.46	2.97	39.39	1.11	13.37	0.0	76.00	90.48	129.87
WEEDING	HAND HOEING (2 HRS)	MAY						9.00	0.0	9.00	9.00
WEEDING	HAND HOEING (2 HRS)	JUNE						9.00	0.0	9.00	9.00
HARVEST PREP	HAND LABOR-4 HRS	JUNE						18.00	0.0	18.00	18.00
HARVEST	HAND PICK FRESH	JUNE						300.00	200.00	500.00	500.00
HARVEST	HAND PICK PROCESS	JUNE						500.00	0.0	500.00	500.00
SUPV LABOR	(2) LABORERS	JUNE						180.00	0.0	180.00	180.00
HAUL BERRIES	1 TON TRUCK (USED)	JUNE	4.50	5.40	46.83	31.07	24.30	0.0	0.0	55.37	102.20
HARVEST	HAND PICK FRESH	JULY						300.00	0.0	300.00	300.00
HARVEST	HAND PICK PROCESS	JULY						250.00	0.0	250.00	250.00
SUPV LABOR	(2) LABORERS	JULY						180.00	0.0	180.00	180.00
HAUL BERRIES	1 TON TRUCK (USED)	JULY	1.50	1.80	15.61	10.36	8.10	0.0	0.0	18.46	34.07
IRRIGATION	LABOR, ELECTRICITY AND REPAIRS	JULY		4.00		21.64		16.00		37.64	37.64
CLEAN UP	HAND LABOR - 2 HOURS	AUG						9.00	0.0	9.00	9.00
MOW BERRIES	30HP, FLAIL MOWER	AUG	0.46	0.55	7.20	0.29	2.50	0.0	0.0	2.78	9.98
APPLY INSECT	30HP, 100 GAL SPRAYER	AUG	1.23	1.49	19.69	0.55	6.68	0.0	77.25	84.49	104.18
FERTILIZE	30HP, 2R-CULTI W/FERT ATTACH	AUG	0.95	1.15	12.46	0.47	5.16	0.0	47.40	53.03	65.49
IRRIGATION	LABOR, ELECTRICITY AND REPAIRS	AUG		4.00		21.64		16.00		37.64	37.64
CUT RUNNERS	30HP, 2 ROW CULTIVATOR	OCT	0.95	1.15	12.46	0.47	5.16	0.0	0.0	5.63	18.09
SPRAY WEEDS	30HP, 100 GAL SPRAYER	OCT	1.23	1.49	19.69	0.55	6.68	0.0	33.20	40.44	60.13
TOTAL PER ACRE					225.19	89.72	90.49	1796.00	452.05	2428.26	2653.46

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STRAWBERRY ESTABLISHMENT COSTS, ESTABLISHMENT YEAR
WESTERN WASHINGTON DATA, 10 ACRE ENTERPRISE - 1982

TABLE 2: SUMMARY OF ESTABLISHMENT COST PER ACRE

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
SOILTEST	ACRE	4.50	1.00	4.50	----------
NEMOTODE TEST	ACRE	2.50	1.00	2.50	----------
ROUNDUP	GAL.	83.00	0.75	62.25	----------
CUST PLOW	ACRE	25.00	1.00	25.00	----------
DOLOMITE	TONS	97.50	1.00	97.50	----------
CUST LIME	ACRE	3.50	1.00	3.50	----------
CUST FUMIGATE	ACRE	30.00	1.00	30.00	----------
TERROCIDE 54/45	GAL.	27.00	11.00	297.00	----------
10-20-20	LBS.	0.118	500.00	59.25	----------
STRAW PLANTS	HD.	4.000	110.00	440.00	----------
10-15-15	LBS.	0.113	600.00	68.10	----------
STRAW PLANTS (REPLANT)	HD.	4.10	5.50	22.55	----------
HAND WEED	HR.	4.50	6.00	27.00	----------
METASYSTOX R	GAL.	30.80	1.50	46.20	----------
DEVRINOL 50WP	LBS.	8.30	4.00	33.20	----------
TENORAN 50WP	LBS.	7.60	2.00	15.20	----------
OVERHEAD	DOL.	0.05	1615.96	80.80	----------
PLANT LABOR	HR.	4.50	8.00	36.00	----------
REPLANT LABOR	HR.	4.50	1.50	6.75	----------
10-20-20	LBS.	0.118	400.00	47.40	----------
MACHINERY REPAIR	ACRE	5.87	1.00	5.87	----------
TRACTORS REPAIR	ACRE	5.43	1.00	5.43	----------
IRRIGATION REPAIR	ACRE	35.04	1.00	35.04	----------
IRRIGATION FUEL	ACRE	8.24	1.00	8.24	----------
LABOR(TRACTOR & MACHINERY)	HOUR	4.50	26.16	117.74	----------
LABOR(IRRIGATION)	HOUR	4.00	8.00	32.00	----------
INTEREST ON OP. CAP.	DOL.	0.12	737.94	88.55	----------
TOTAL VARIABLE COST				$1697.57	----------
FIXED COSTS				$	
MACHINERY DEPRECIATION	ACRE	90.64	1.00	90.64	----------
MACHINERY INTEREST	ACRE	74.34	1.00	74.34	----------
MACHINERY INSURANCE	ACRE	3.72	1.00	3.72	----------
TRACTORS DEPRECIATION	ACRE	66.90	1.00	66.90	----------
TRACTORS INTEREST	ACRE	80.28	1.00	80.28	----------
TRACTORS INSURANCE	ACRE	4.01	1.00	4.01	----------
IRRIGATION DEPRECIATION	ACRE	43.84	1.00	43.84	----------
IRRIGATION INTEREST	ACRE	65.76	1.00	65.76	----------
MANAGEMENT CHARGE (5% VARIABLE COST)		1697.57	0.05	84.88	----------
LAND RENT	ACRE	125.00	1.00	125.00	----------
TOTAL FIXED COSTS				$ 639.36	----------
TOTAL COSTS				$2336.93	----------

STRAWBERRY PRODUCTION COSTS - FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
WESTERN WASHINGTON 10 ACRE ENTERPRISE - 1982

TABLE 2A: SUMMARY OF PRODUCTION COST PER ACRE AND BREAKEVEN SELLING PRICES PER UNIT

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
VARIABLE COSTS					
PREHARVEST				$	
TENORAN	LBS.	7.60	2.00	15.20	----------
GUTHION	LBS.	6.00	0.50	3.00	----------
METASYSTOX R	GAL	34.00	1.50	51.00	----------
RONILAN 50WP	LBS.	25.00	1.00	25.00	----------
FURADAN	GAL	51.50	1.50	77.25	----------
10-20-20	TONS	0.118	400.00	47.40	----------
DEVRINOL 50WP	LBS.	8.30	4.00	33.20	----------
MACHINERY REPAIR	ACRE	2.33	1.00	2.33	----------
TRACTORS REPAIR	ACRE	2.68	1.00	2.68	----------
IRRIGATION REPAIR	ACRE	35.04	1.00	35.04	----------
IRRIGATION FUEL	ACRE	8.24	1.00	8.24	----------
LABOR(TRACTOR & MACHINERY)	HOUR	4.50	12.91	58.09	----------
LABOR(IRRIGATION)	HOUR	4.00	8.00	32.00	----------
INTEREST ON OP. CAP.	DOL.	0.12	188.85	22.66	----------
OVERHEAD	DOL.	0.05	2522.40	126.12	----------
SUBTOTAL, PRE-HARVEST				$ 539.22	----------
HARVEST COSTS				$	
HARV PREP	HR.	4.50	4.00	18.00	----------
HAND LABOR	FLAT	1.50	400.00	600.00	----------
HAND LABOR	FLAT	2.00	375.00	750.00	----------
SUPV LABOR	HR.	10.00	36.00	360.00	----------
CLEAN UP LABOR	HR.	4.50	2.00	9.00	----------
FLATS	FLAT	0.50	400.00	200.00	----------
MACHINERY REPAIR	ACRE	6.93	1.00	6.93	----------
MACHINERY FUEL	ACRE	30.00	1.00	30.00	----------
MACHINERY LUBE	ACRE	4.50	1.00	4.50	----------
LABOR(TRACTOR & MACHINERY)	HOUR	4.50	7.20	32.40	----------
SUBTOTAL, HARVEST				$2015.81	----------
TOTAL VARIABLE COST				$2550.04	----------
BREAKEVEN PRICE, VARIABLE COSTS AT 10,000	POUNDS/ACRE			.25	----------
FIXED COSTS				$	
MACHINERY DEPRECIATION	ACRE	73.43	1.00	73.43	----------
MACHINERY INTEREST	ACRE	61.43	1.00	61.43	----------
MACHINERY INSURANCE	ACRE	3.07	1.00	3.07	----------
TRACTOR DEPRECIATION	ACRE	33.01	1.00	33.01	----------
TRACTOR INTEREST	ACRE	39.61	1.00	39.61	----------
TRACTOR INSURANCE	ACRE	1.98	1.00	1.98	----------
IRRIGATION DEPRECIATION	ACRE	43.84	1.00	43.84	----------
IRRIGATION INTEREST	ACRE	65.76	1.00	65.76	----------
MANAGEMENT CHARGE (5% VARIABLE COST)		2550.04	0.05	127.50	----------
PRORATED ESTAB. COST	ACRE	2336.93	0.42	981.51	----------
LAND RENT	ACRE	125.00	1.00	125.00	----------
TOTAL FIXED COSTS				$1556.14	----------
TOTAL COSTS				$4106.18	----------
BREAKEVEN PRICE, TOTAL COSTS AT 10,000	POUNDS/ACRE			.41	----------

STRAWBERRY PRODUCTION COSTS - FULL PRODUCTION
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TABLE 3: SUMMARY OF RECEIPTS, COSTS, AND PROFITABILITY PER ACRE

	UNIT	PRICE OR COST/UNIT	QUANTITY	VALUE OR COST	YOUR FARM
GROSS RECEIPTS FROM PRODUCTION					
STRAWBERRIES - PROCESSOR	POUNDS	.43	6000	2580.00	----------
STRAWBERRIES - DIRECT MARKET	POUNDS	.63	4000	2520.00	----------
				---	
1. TOTAL RECEIPTS				$5100.00	----------
LESS: TOTAL VARIABLE COST (TABLE 2A)				$ 2550.04	----------
2. RETURNS OVER VARIABLE COST				$2549.96	----------
LESS: MACHINERY FIXED COST				$ 322.13	----------
PRORATED ESTAB. COST				$ 981.51	----------
3. RETURNS TO LAND AND MANAGEMENT				$1246.32	----------

NOTE: STRAWBERRY PRICES PAID BY PROCESSORS ARE SUPPLY SENSITIVE AND HAVE RANGED FROM 25 CENTS TO THE CURRENT 43 CENTS IN THE LAST FIVE YEARS.

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STRAWBERRY PRODUCTION COSTS - FULL PRODUCTION
FOR DIRECT MARKETING AND PROCESSING
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TABLE 4: MONTHLY SUMMARY OF DIRECT CASH EXPENSES AND LABOR REQUIREMENTS

CATEGORY	UNIT	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	PRICE	TOTAL	VALUE
OPERATING INPUTS:																
TENORAN	LBS.	0.0	0.0	0.0	2.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.60	2.00	15.20
WATER	HR.	0.0	0.0	0.0	2.00	2.00	2.00	0.0	0.0	0.0	0.0	0.0	0.0	4.50	6.00	27.00
GUTHION	LBS.	0.0	0.0	0.0	0.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.00	0.50	3.00
METASYSTOX R	GAL	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.00	1.50	51.00
RONILAN 50WP	LBS.	0.0	0.0	0.0	0.0	1.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	25.00	1.00	25.00
HARV PREP	HR.	0.0	0.0	0.0	0.0	0.0	4.00	0.0	0.0	0.0	0.0	0.0	0.0	4.50	4.00	18.00
HAND LABOR	FLAT	0.0	0.0	0.0	0.0	0.0	200.00	200.00	0.0	0.0	0.0	0.0	0.0	1.50	400.00	600.00
HAND LABOR	FLAT	0.0	0.0	0.0	0.0	0.0	250.00	125.00	0.0	0.0	0.0	0.0	0.0	2.00	375.00	750.00
SUPV LABOR	HR.	0.0	0.0	0.0	0.0	0.0	18.00	18.00	0.0	0.0	0.0	0.0	0.0	10.00	36.00	360.00
FURADAN	GAL	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.50	0.0	0.0	0.0	0.0	51.50	1.50	77.25
CLEAN UP LABOR	HR.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.00	0.0	0.0	0.0	0.0	4.50	2.00	9.00
10-20-20	TONS	0.0	0.0	0.0	0.0	0.0	0.0	0.0	400.00	0.0	0.0	0.0	0.0	0.12	400.00	47.40
DEVRINOL 50WP	LBS.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.00	0.0	0.0	8.30	4.00	33.20
FLATS	FLAT	0.0	0.0	0.0	0.0	0.0	400.00	0.0	0.0	0.0	0.0	0.0	0.0	0.50	400.00	200.00
OVERHEAD	DOL.	0.0	0.0	0.0	0.0	0.0	2422.72	0.0	0.0	0.0	0.0	0.0	0.0	0.052	422.72	121.14
TRACT REPAIR COST	ACRE	0.0	0.0	0.0	0.86	0.62	0.0	0.0	0.66	0.0	0.55	0.0	0.0			2.68
EQUIP FUEL COST	ACRE	0.0	0.0	0.0	0.0	0.0	22.50	7.50	0.0	0.0	0.0	0.0	0.0			30.00
EQUIP LUBE COST	ACRE	0.0	0.0	0.0	0.0	0.0	3.37	1.12	0.0	0.0	0.0	0.0	0.0			4.50
EQUIP REPAIR COST	ACRE	0.0	0.0	0.0	0.72	0.49	5.19	1.73	0.65	0.0	0.48	0.0	2.00			11.26
IRRIG FUEL COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	4.12	4.12	0.0	0.0	0.0	0.0			8.24
IRRIG REPAIR COST	ACRE	0.0	0.0	0.0	0.0	0.0	0.0	17.52	17.52	0.0	0.0	0.0	0.0			35.04
TOTAL COST	ACRE	0.0	0.0	0.0	28.78	86.11	1359.20	762.00	156.60	0.0	34.22	0.0	2.00			2428.91
		LABOR REQUIREMENTS BY MONTH														
MACHINERY LABOR	HR.	0.0	0.0	0.0	4.12	2.97	5.40	1.80	3.19	0.0	2.63	0.0	0.0			20.11
IRRIGATION LABOR	HR.	0.0	0.0	0.0	0.0	0.0	0.0	4.00	4.00	0.0	0.0	0.0	0.0			8.00
TOTAL LABOR	HR.	0.0	0.0	0.0	4.12	2.97	5.40	5.80	7.19	0.0	2.63	0.0	0.0			28.11
IRRIGATION WATER	INCH	0.0	0.0	0.0	0.0	0.0	0.0	4.00	4.00	0.0	0.0	0.0	0.0			8.00

TABLE 5 -- STRAWBERRY RETURNS OVER TOTAL COSTS AT VARIOUS YIELDS AND PRICES[1/]

CENTS PER POUNDS

YIELD POUNDS/ACRE	30	35	40	45	50	55	60	65	70
4,000	-1694	-1494	-1294	-1094	-894	-694	-494	-294	-94
5,000	-1595	-1345	-1095	-845	-595	-345	-95	154	404
6,000	-1496	-1196	-896	-595	-296	3	303	603	903
7,000	-1395	-1047	-697	-347	2	352	702	1052	1402
8,000	-1298	-898	-498	-98	301	701	1101	1501	1901
9,000	-1199	-749	-299	150	600	1050	1500	1950	2400
10,000	-1100	-600	-100	399	899	1399	1899	2399	2899
11,000	-1001	-451	98	648	1198	1748	2298	2848	3398
12,000	-902	-302	297	897	1497	2097	2697	3297	3897
13,000	-803	-153	496	1146	1796	2446	3096	3746	4396
14,000	-704	-4	695	1395	2095	2795	3495	4195	4895
15,000	-605	144	894	1644	2394	3144	3894	4644	5394

1/ The price in cents per pound and variable harvest costs assume 60 percent of the fruit is sold to a processor and 40 percent is direct-marketed.