Strawberry Production Manual

For Growers on the Central Coast

Second edition. Published November 2015

Contents

Preface

This manual is designed to help Central Coast strawberry growers with many aspects of managing strawberry production. The manual was produced as a collaborative effort between several Central Coast Resource Conservation Districts (RCDs), the University of California Cooperative Extension (UCCE), the Farm Service Agency (FSA), and the Natural Resource Conservation Service (NRCS) and several local strawberry growers.

The information contained in this publication is intended to compliment, not substitute, technical information. It is not intended to be a detailed guide. It is the reader's responsibility to follow the laws and regulations. Utilize the technical assistance from providers such as UCCE, NRCS, and RCD to obtain additional information.

Coordinated by the Cachuma Resource Conservation District with CDFA, NRCS and RCD funding

Authors and Contributing Editors: RCD, UCCE, NRCS, and FSA

RESOURCE CONSERVATION DISTRICT

CENTRAL COAST RECOURCE CONSERVATION DISTRICTS

Strawberry Production Manual For Growers on the Central Coast

Second edition, also available in Spanish

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Contributors

Authors

Mark Bolda, UCCE: Variety Selection, Macronutrients, and Micronutrients sections

Surendra K. Dara, UCCE: IPM Fundamentals, Pest, and Disease sections

CRCD Staff: Julie Fallon, Misael Sanchez, and Kevin Peterson coauthors of other sections

Technical Editors

Surendra K. Dara, Ben Faber, UCCE, Mark Bolda, UCCE; CRCD Staff: Julie Fallon, Misael Sanchez, and Kevin Peterson

Production

2015 Second edition Spanish-language Production Manual: CRCD: Misael Sanchez, Lauren Barnum

2015 English-language Production Manual: CRCD: Anne Coates, Lauren Barnum, Julie Fallon

Graphic Design and Illustration: Maria Gracia Sarabia/mg.sarabia@yahoo.com

Layout: Maria Gracia Sarabia/Terri Lajda

Photography and Cover Design: Terri Lajda

The following publications were widely consulted in the elaboration of this manual:
UC IPM for Strawberries, publication #3351
University of California Cost Studies
Erosion Control adapted from Controlling erosion in the hills and agricultural roads elaborated by RCD of Monterey County, RCD of Santa Cruz County, NRCS

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Your Business Plan

A business plan is an essential roadmap for business success. This living document generally projects 3-5 years ahead and outlines the route a company intends to take. Components of a business plan should include:

1 Goals

Goals should be aligned with personal values and interest in business profitability. It usually takes considerable thought to clearly define and prioritize goals. When working with family and partners, it's important that goals be discussed and agreed upon. Examples may include:

- To support myself and my family
- To have the best quality strawberries in the county
- To grow environmentally-friendly strawberries
- To get the best price
- To create a friendly and productive working environment

The next step is to determine how achievable the goals are. If they seem achievable, then the business plan can determine the methods for achieving these goals as well as a projected timeline. Goals may be short-term or long-term. Often the short-term goals help achieve long-term goals. As you assess your goals, several questions may come to mind:

- How much capital do you need to grow 20 acres of strawberries?
- Do you need to borrow capital from a bank?
- Do you have forecasted income statements or cash flow statements?
- Do you have capital to lease the land?
- Do you know from which certified nursery you're going to purchase your transplants?
- How are you going to make sure that you have enough labor for the season?
- What are the pesticide regulations?
- What are the water quality regulations?
- If you have a contract to grow strawberries, are you aware of all of your responsibilities and penalties if you fail to meet those responsibilities?

2 Financial Plans

Develop financial projections after identifying and agreeing upon clear goals. Financial planning requires that each aspect of your business has been carefully analyzed.

Detailed cost and return estimates for Central Coast strawberries are available at www.coststudies.ucdavis.edu. Cost studies are specific to production areas Santa Cruz & Monterey, Santa Barbara & San Luis Obispo, and Ventura; organic production; and production of second-year strawberries. These UCCE publications are designed to help in constructing financial projections. They are currently not in Spanish so bilingual UCCE/RCD/NRCS personnel may be helpful in using them. Although not all cost estimates in these studies will apply to each farming operation and they do not assess risk factors, they list detailed cost considerations.

Estimated labor and equipment costs related to:

- Land Preparation - disc, rip, level field; shape beds, plastic mulch
- Plant Establishment - cost of transplants, planting
- Fertilizer and Soil Amendments - prior to planting and in-season
- Pest, Weed, and Disease Management
- Harvest
- Year-end Field Cleanup

Important

Keep Records: It is useful to include maps and photos (photo documentation). Obtain maps from the NRCS and RCD.

Your Business Plan

Costs are also considered for:

- Land Rental or Property Taxes
- Insurance
- Interest on Loans
- Office Expenses – supplies, accounting, bookkeeping, legal fees, regulatory expenses like the Ag Order/Ag Waiver
- Food Safety – program, audits
- Assessments – California Strawberry Commission (CSC) fees per tray
- Equipment – depreciation, expected useful life, fuel, repair
- Rentals – sprinkler pipe, portable toilets
- Crop Consultant – PCA, CCA

Returns on yield are estimated based on historic purchase price by cooler or direct sales. Yield is generally stated in trays per acre for fresh market and pounds per acre for freezer market.

3 Risk Management Plan

The business owner assumes the risks associated with producing and marketing strawberries. Upfront costs and risks are significant. It's important to have contingency plans in place for when things go wrong. For example, if sufficient labor to harvest is not available what might the grower do to bring the crop to market? Other common risks include pests, disease, frost damage, rain damage, and slumps in market prices.

Risks can be minimized by careful planning. This manual will help address considerations that will allow for advance planning helping reduce risks. Contingency plans should also be in place. The numerous inherent risks associated with purchasing, growing, harvesting, and selling strawberries cannot be overstated.

4 Administration Plan

Know and agree about who is to be in charge of what tasks and who will be performing them.

5 Operations Plan

Day-to-day operations should be considered. A calendar is needed to determine when tasks are to be accomplished. Recordkeeping of what has been performed is also important. Recordkeeping should be precise and detailed. The Financial and Administration Plans will feed into the Operations Plan.

Examples include:

- Field Labor – planting, scouting, weeding, leaf and runner removal, harvesting dates
- Fertilizer Applications – when and how much
- Irrigation Applications – when and for how long
- Pesticide Applications – the type of pesticide and the application rate

It is important to consider how operational tasks interact. For example, fields cannot be accessed during pesticide reentry intervals. Berries picked for fresh market the same day as they are irrigated may not be as firm for shipping.

6 Marketing Plan

Many small-scale growers sell directly to "coolers" so they are not responsible for the marketing end of production. If you do decide on an alternative marketing strategy, you will need to spend more time and money selling your product in hopes of receiving more profit.

Your Business Plan

Financial Assistance

The United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), and Farm Service Agency (FSA) offer several financial assistance programs for farmers.

The Natural Resource Conservation Service provides technical assistance for the conservation and opportunity of funds for agricultural producers through the following programs:

- **Environmental Quality Incentives Program** (EQIP) to help, plan, and implement conservation practices to address concerns about natural resources.
- **Wildlife Habitat Incentive Program** (WHIP) to develop and better wildlife habitats on agricultural land.
- **Working Lands for Wildlife** To combat the decrease of seven specific species of wildlife.
- **New and local programs are available**, such as America's Great Outdoors Initiative of the Monterey Bay region. Ask about this at your local NRCS.

FSA Crop Insurance

The Non-Insured Disaster Assistance Program (NAP) provides financial assistance to producers of non insurable crops when low yields, loss of inventory or prevented planting occur due to a natural disaster. An eligible producer is a landowner, tenant, or sharecropper who shares in the risk of producing an eligible crop and is entitled to an ownership share of that crop. To be eligible for NAP, an individual's or entity's average nonfarm adjusted gross income (AGI) cannot exceed $500,000.

FSA Disaster Assistance

The Supplemental Revenue Program (SURE) provides assistance to producers suffering crop losses due to natural disasters. To receive SURE payments, an eligible producer must have a qualifying loss. A qualifying loss means at least a 10 percent production loss affecting one crop of economic significance due to a disaster on a farm in a disaster county. Producers outside a declared disaster county, but with production losses greater than or equal to 50 percent of the normal production on the farm (expected revenue for all crops on the farm), also qualify for SURE.

Important

Farmers often have two contracts: one for the fresh market and one for the cooler. If you plan on selling to various buyers, it is important to stay up to date with current market prices to determine the best indicator of actual yield.

Farm Service Agency (FSA) Loans

© Photo by Terri Lajda, CRCD

Your Business Plan

FSA Beginning Farmers and Rancher Loans

The Agency targets a portion of its loan funds to small and beginning farmers and ranchers. A beginning farmer is defined as one whom:

- Has not operated a farm or ranch for more than 10 years
- Does not own a farm or ranch greater than 30 percent of the median size farm in the county as determined by the most current Census for Agriculture
- Substantially participates in the operation

FSA Farm Operating Loans

Eligible applicants may obtain direct loans for up to a maximum indebtedness of $300,000 and guaranteed loans for up to a maximum indebtedness of $1,302,000 (amount adjusted annually for inflation). The repayment term may vary, but typically it will not exceed seven years for intermediate-term purposes.

FSA Farm Ownership Loan

The maximum loan amount for a Direct Farm Ownership Loan is $300,000. There is no required down payment. Applicants must have participated in the day-to-day management of a farm or ranch for at least 3 years.

FSA Emergency Loans

The maximum loan amount for an Emergency loan is $500,000. These loans help producers who own or operate located in a county declared by the President or designated by the Secretary of Agriculture as a primary disaster area or quarantine area. All counties contiguous to the declared designated, or quarantined primary counties also are eligible for Emergency loans. Emergency loan funds may be used to:

- Restore or replace essential property
- Pay all or part of production costs associated with the disaster year
- Pay essential family living expenses
- Reorganize the farming operation
- Refinance certain debts, excluding real estate

FSA Microloans

Eligible applicants may obtain a microloan for up to $35,000. The Microloan program is designed to serve beginning farmers and small family farm operations. The application process for microloans will be simpler, requiring less paperwork to fill out. The repayment term may vary and will not exceed seven years. It is best to repay these loans as quickly as possible because other FSA loans cannot be applied for until while this loan is in repayment. Microloans can be used for all approved operating expenses as authorized by the FSA Operating Loan Program, including but not limited to:

- Initial start-up expenses
- Annual expenses such as seed, fertilizer, utilities, land rents
- Marketing and distribution expenses
- Family living expenses
- Purchase of equipment and other materials essential to farm operations
- Minor farm improvements such as irrigation, wells and coolers
- Hoop houses to extend the growing season
- Delivery vehicles

Administration

8 Marketing

Marketing has 4 components, called the 4 P's:

- Product
- Price
- Place
- Promotion

You need to think of all of these and reassess every season.

Product

It seems obvious that your product is strawberries, but you have the choice of what variety to plant, when to plant, and growing techniques.

Varieties differ in planting dates. Consider choosing different varieties so you can harvest through a longer season or varieties that will be ready for harvest at times when prices in the past have been highest.

- Consider growing methods that help with timing of production such as colored mulch or hoop houses
- Consider extending the harvest period through cutbacks
- Consider growing organically or sustainably as a way to differentiate your product from other farmers'
- Attend meetings and stay in touch with your local UC Strawberry and Small Farm Advisors to stay informed of current research

Price

Strawberry sales follow supply and demand. To make money selling strawberries you must sell strawberries at the right time. If you have a substantial yield when the market price is low then you may not see a profit.
Each Central Coast production area peaks during different times in the season. No matter where you are growing, you want to sell strawberries when the market supply is low and prices are high.

You need to watch the market and keep track of prices through the year so you can make good Product decisions.

Place to Sell

- Contract with a marketing company or "cooler" - most common for small-scale growers
- Direct Marketing - selling directly to the consumer through Farmers Markets, Community Sustainable Agriculture (CSAs), roadside farm stands, or U-picks
- Wholesale marketing – selling to local restaurants, grocers, or institutions such as schools, senior homes, correctional and mental health facilities
- Contract as a member of an agricultural marketing cooperative or "grower co-op"
- Sell as local specialty 'value added' products – jams, ice cream, and other processed commodities

For more information or assistance, you may also want to contact:

- Agriculture and Land-Based Training www.albafarmers.org strives to develop marketing alternatives for small-scale, limited- resource, Spanish-speaking farmers.
- Community Alliance with Family Farmers (CAFF) http://caff.org advocates for California's family farmers, sustainable agriculture, and the "buy local" campaign. One way that CAFF is working towards the development of strong partnerships between family farmers and their communities is by provide marketing assistance and materials to farmers.

Promotion

The type of promotion we are familiar with as consumers, happens at the retail point. If you are going to do Direct Marketing, you need to promote yourself and your product to get customers to want to buy from you. That means making certain your product looks good and making sure you have signs that bring people to your stand.
If you are working through a cooler, wholesaler, or grower co-op, you need to "promote" yourself as a good farmer who can deliver quality product at specific times.

Environment and Safety

The land manager or manager is legally required to be familiar with current laws and regulations.
Requirements change periodically so stay in contact with regulators.

Water Quality

Regional Water Quality Control Boards (RWQCB)

Growers are responsible for clean water leaving the property to surface water and groundwater.

- For each property, either the landowner or land manager of irrigated agriculture must be enrolled in the 'Ag Order/Ag Waiver' program.
- If you lease, you can ask the landowner for the enrollment 'AW#' and, for Region 3, a copy of the 'Farm Water Quality Plan' (Required in Region 3).
  - Follow the management practices listed in this plan.
  - Keep a written record of plan updates and practices used to benefit water quality.

Contact your RWQCB for a list of current monitoring, educational and reporting requirements.

- **Region 3** (Salinas/Watsonville and Santa Maria areas)
  www.swrcb.ca.gov/centralcoast/water_issues/programs/ag_waivers/index.shtml
- **Region 4** (Ventura/Oxnard)
  www.waterboards.ca.gov/losangeles/water_issues/programs/tmdl/waivers/index.shtml

Worker Safety

CalOSHA– Has many requirements to protect workers' health and safety. Examples:

→ There must be shade, water and clean portable toilets for workers

→ Employers need to provide workers with liability insurance

→ Required Postings:

- Current minimum wage
- Emergency call numbers
- Hotline if ill or mistreated

→ **Material Safety Data Sheets (MSDS)** are required for Pesticides. These are often available in Spanish. To locate, type the product name 'MSDS' and 'Spanish' into a search engine like google, yahoo, or bing

CalOSHA publications
www.dir.ca.gov/dosh/PubOrder.asp

Food Safety

California Strawberry Commission (CSC) provides:
http://www.calstrawberry.com/commission/fsresources.asp

- Good Agricultural Practices (GAPs) for Food Safety in in English and Spanish
- 'Food Safety Practices for Strawberry Harvest Workers' handbook in English and Spanish
- Food Safety trainings in English and Spanish. Contact: CSC (831) 724-1301

Resources for Regulatory Compliance

- ALBA- Grower's Regulatory Compliance Guide in English and Spanish
  www.albafarmers.org/publications.html
- Central Coast Agricultural Water Quality Coalition provides a free "Farm Water Quality Plan" in English and Spanish and provides help to develop a plan and understand the regulations www.agwaterquality.org
- Agricultural Practices to Protect Water Quality: Illustrated guide for strawberry cultivating in California: UCCE Ventura
  http://ceventura.ucanr.edu/Com_Ag/Ag_Water/Resources_for_Strawberry_in_Ventura/
- Production Manual for Agricultural Conservation and Erosion Control on Hills and Agricultural Roads (English and Spanish): RCD Monterey
  www.rcdmonterey.org/Downloads/PDFs.html

Environment and Safety

Permitting

Several Government Regulatory Agencies require permits for work that requires:

- Grading
- Removal of vegetation
- Work within 100 feet of riparian corridors or streams
- Work that may potentially adversely impact rare, threatened, endangered, or sensitive species and their habitat

Partners in Restoration

Some Counties have a 'Partners in Restoration' permit coordination program that allows the local RCD and NRCS to work with the Regulatory Agencies to manage permits for you, saving time and money. Other counties have agreements with RCDs to facilitate the permitting of agricultural projects.

If you think you may need a permit, contact your local RCD. They can advise you on the permitting requirements for your project.

Pesticide Applications

The Agricultural Commissioner's Office requires certification for the commercial spraying of pesticides. Some considerations are listed here on the Agricultural Commissioner's Website: http://cosb.countyofsb.org/agcomm/agcomm.aspx?id=45267. Much of the following information is adapted from Santa Barbara County Grower's Guide.

1 Plan each Pesticide Application

- Keep current with the Ag Commissioner's Office laws and regulations
- Keep current with the Department of Pesticide Regulation (DPR) about wellhead protection, mixing and loading
- Make sure you have a current Operator Identification Number (OIN) or Restricted Use Permit from your Ag Commissioner's Office
- Train all applicators and employees working in treated fields in both pesticide application and procedures to follow if there is an accident
- If using a California-restricted material, make sure the chemical and site/crop is listed on your current Restricted Material Permit for the County
- Evaluate nearby sensitive sites (schools, residential homes, creeks). Follow Buffer Zone Requirements for Ag-Urban Interface areas
- Obtain and provide necessary Personal Protective Equipment (PPE); medical care information in case of exposure; and decontamination equipment: eyewash, soap, water, paper towels within ¼ mile
- File a Notice of Intent (NOI) 24-hours prior to the proposed application on CA restricted materials with the Ag Commissioner
- Watch the weather, especially rain and wind; adjust or stop the application as needed

Environment and Safety

2 Apply Following Label Instructions

- Signal word: immediate toxicity to humans DANGER > WARNING > CAUTION, in decreasing order
- Know Hazards to Humans and the Environment including bee and beneficial insect toxicity, drift, and groundwater concerns
- Follow Crop, Rate, and Dilution allowed by label
- Know length of Restricted Entry Interval (REI) and Pre-Harvest Interval
- Follow Sign Field Posting requirements on label
- Wear appropriate PPE as instructed by the label

3 After the Application

- Follow procedures for cleaning and storage of PPE and storage and disposal of unused product
- Remove field posting within 3 days after expiration of Restricted Entry Interval (REI).
- Submit Use Report to the Ag Commissioner's Office before the 10th day of the following month and keep records for 2 years

Contacts

Ag Commissioners Office

San Mateo County 650-363-4700
San Benito County 831-637-5344
Santa Clara County 408-918-4600
Santa Cruz County 831-763-8080
Monterey County 831-759-7325
Santa Barbara County 805-934-6200
San Luis Obispo County 805-781-5910
Ventura County 805-388-4343

© Photo by Misael Sanchez, CRCD

Strawberry Plant

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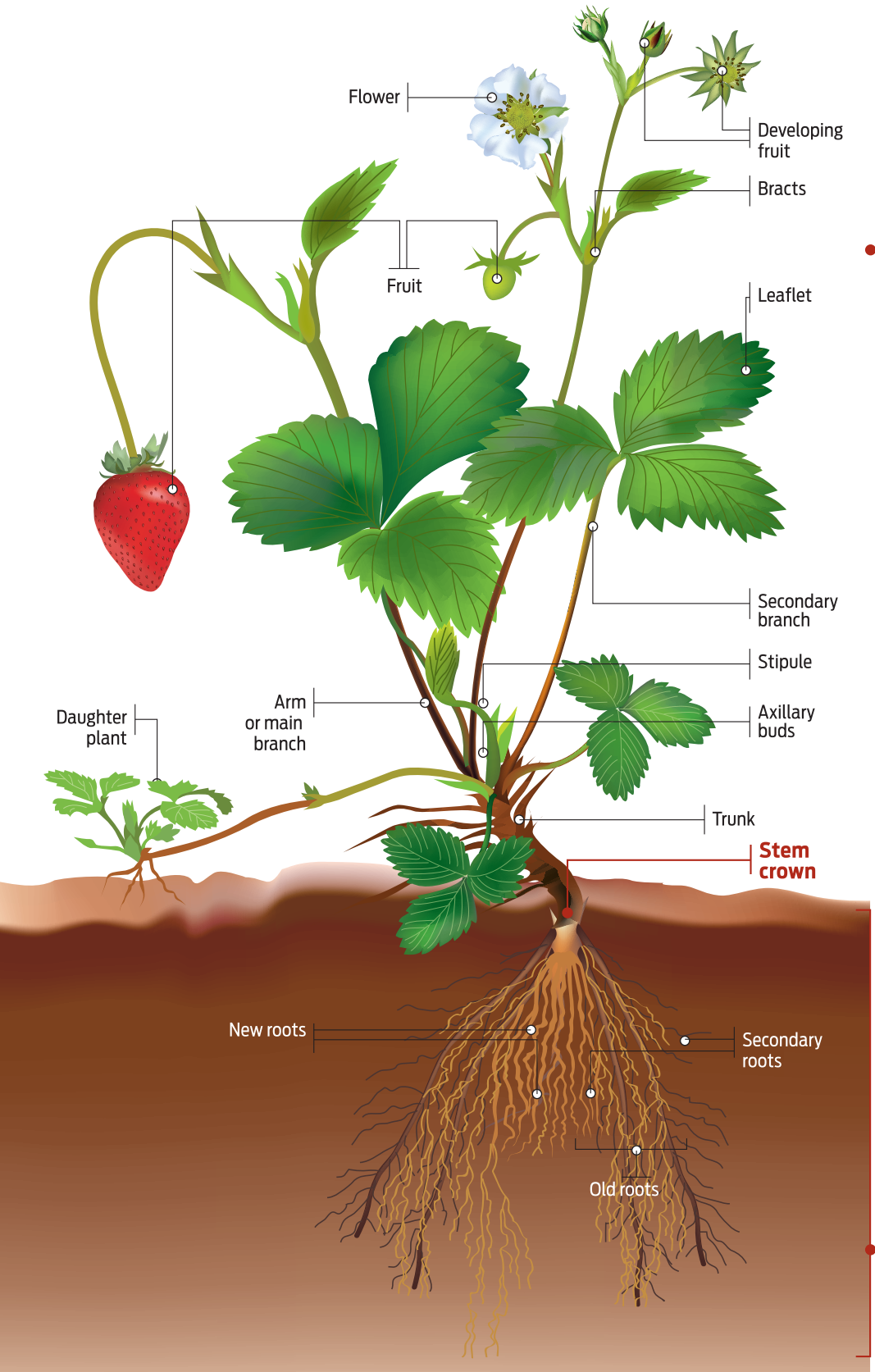
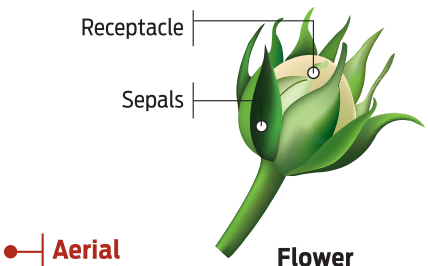
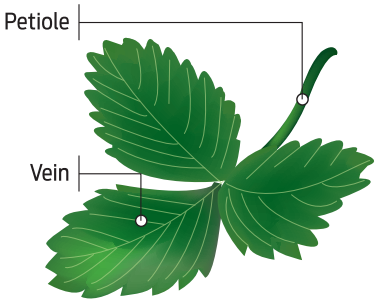
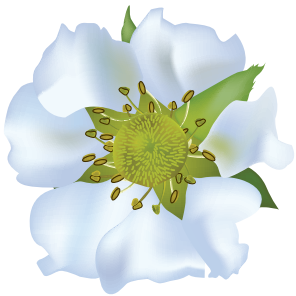
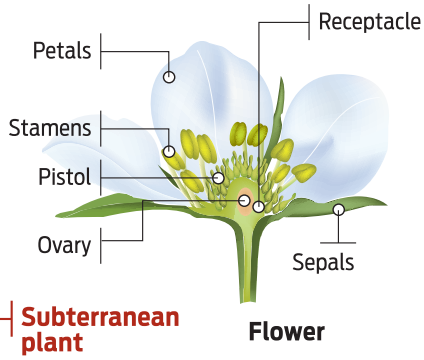
Description











Description

Strawberry plants can reproduce either from seeds or vegetatively. Reproduction by seed is used to develop new varieties. Commercial plantings are grown from these patented varieties.

The strawberry plant sends out stems called stolons, along which the new plants or "daughter plants" form. These are genetically identical to the "mother plant". Central Coast commercial strawberry propagation is accomplished by growing the daughter plants in nurseries then selling them as transplants for planting.

Flowers

Flowers originate from auxiliary buds, developing in clusters growing out of each bract. The primary flower is the first flower to form. Secondary flowers develop under the primary flower. Tertiary flowers can develop under these and the pattern continues.

Fruit

Typically 5-6 fruits develop above each bract, but sometimes there can be more. Primary flowers develop into fruit first and also develop into the largest berries. Secondary flowers develop second and develop into the second largest berries and so on.

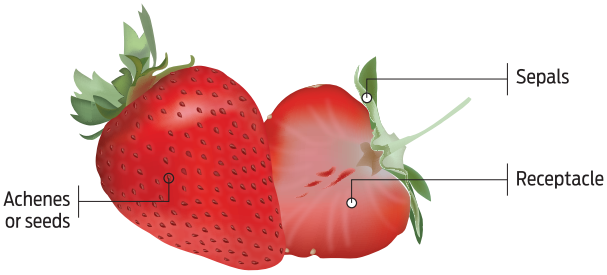
Fruit development can be damaged by different factors such as short periods of frosts, insufficient soil moisture, and pest damage. Because damage may occur when flowers and fruit are in different developmental stages on the plant, a single incidence can caused reduced production for up to 8 weeks.

- Technically the fruit are the many, tiny achenes on the skin of the berry (receptacle) that look like seeds. The achenes develop from pollinated pistols. Since the entire receptacle is the part that people like to eat, conventionally the receptacle is the part called the fruit or berry.

Crown

The crown is the central part of the strawberry pant that rests on the soil surface and forms roots at the base. The crown is the main growing point from which axillary buds form producing both vegetative (green) growth and flower clusters.

Seed



Fruit

Photo by Julie Fallon, CRCD

Description

Pollination

Strawberries pollinate by wind, so bees are not necessary for pollination though they do help with cross-pollination (the pollen from one strawberry plant fertilizing another). Pollen from the stamens is blown onto the pistols. Development of flower to mature fruit takes 4 to 8 weeks, depending on temperature.

Leaves

Strawberry leaves are composed of three leaflets so the type of leaf is “trifoliate”. Leaves grow in a spiral pattern with the newest leaves in the center of the spiral. Leaves are formed throughout the growing season, every 8-12 days. Nutrients that are mobile within the plant will travel to the newer leaves to help with their development. Mature leaves remain alive on the plant for several months.

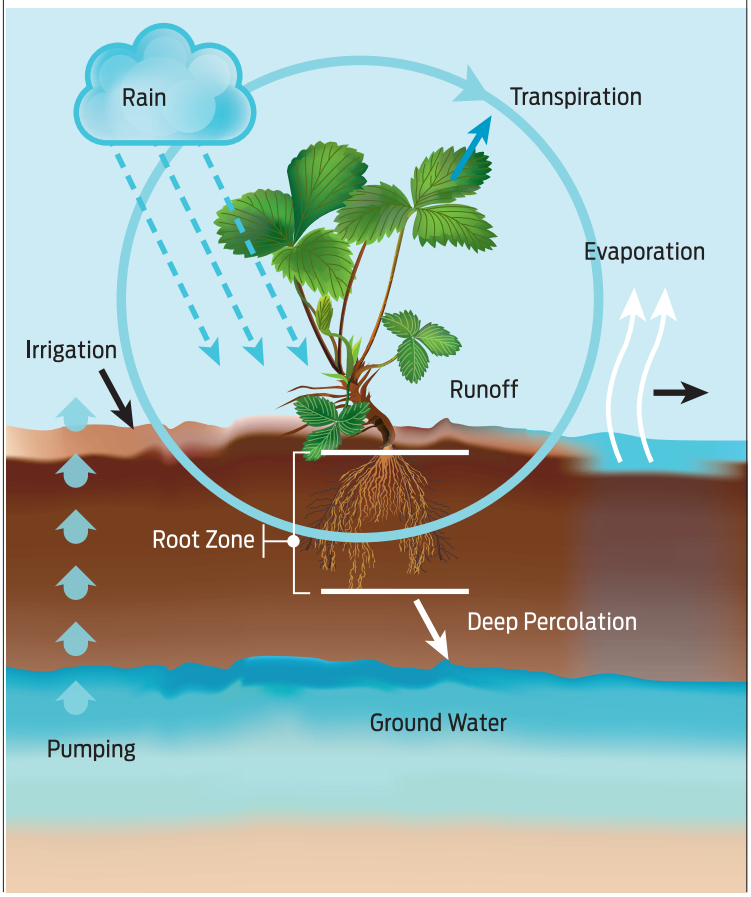
Leaves participate in several plant processes and functions:

- **Photosynthesis:** captures the energy in the form of sunlight to produce sugars. Sugars are then translocated, or moved within the plant, from leaves to fruit. In winter, sugars are translocated into roots for storage as starch to be used as energy for spring growth
- **Respiration:** converts the sugars into energy
  Shade much of the delicate new growth from sunlight.
  Shade soil around the plant to help retain soil moisture.
- **Transpiration:** releases water into the atmosphere to help cool the plant. Transpiration takes place when ‘stomata’ open. Stomata are pores located on the leaves, especially the leaf undersides. Plants transpire more when it is hot. Strawberry plants have many stomata and relatively shallow roots. They must be watered frequently so they don’t dry out, especially during hot, dry and windy days that pull moisture from the plant. Strawberry plants transpire more when it is hot especially when days are longer because more hours of sunlight equates to more transpiration.

Too many leaves, for example from too much nitrogen, can cause:

Some leaves shade others reducing sugar production so berries may not be as flavorful.
An increase of diseases like botrytis since plants do not dry out as well under a thick leaf canopy.

Water Cycle



Description

Roots

Roots grow in the top 12-16" of soil, with about 75% of the active roots in the top 6" of soil. Soil near the surface is the most aerated. Plant roots need oxygen to perform respiration. Many soil microorganisms that help release nutrients from the soil also need oxygen and so are in found near the soil surface. Respiration is important because it allows the strawberry plants to store energy. The roots act as a long-term storage site for respiration. Soil temperature above 45-degrees Fahrenheit favors root growth, with ideal temperature being 55-degrees Fahrenheit. Plastic mulch is used to increase soil temperatures for roots.

Primary roots are also called structural or peg roots which are usually 20-30 per plant. They can live for 1 to 2 years. Secondary roots are fine roots that develop from the primary roots and are called feeder or white roots. They live only for a few days or weeks. While primary roots store starch produced by the plant, secondary roots absorb water and nutrients from the soil.

Roots:

- Capture water from the soil for moving nutrients through the plant and for transpiration
- Capture nutrients from the soil for plant growth
- Provide structural support for the plant
- Store sugars as starch in winter to be used for spring growth
- Respire: use sugars as energy for growth

Stolons

Long days and temperatures over 59-degrees promote the development of stolons, also called "runners". These are stems and vegetative leaves of the plant that grow through soil surface. New plants develop with time with their own root system. This is a natural plant response under these conditions that drives the reproductive stage. The strawberry plant uses stolons for propagation. Removing stolons allows more energy to go towards leaf and flower production.

Planting

Plant establishment

Fruit production

Pruning

End of season

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Transplant Selection

Strawberries are perennial meaning they can be grown for multiple years. Most Central Coast strawberries are only grown for a single season due to yield reductions, smaller sized fruit, and increased pest problems common in second year “cut back” plantings.

How transplants are grown, handled, and planted affect their ability to establish and to achieve full production.

Select high-quality, disease-free transplants

- Transplants can be contaminated with viruses, nematodes, fungi, and pests. ‘Certified’ transplants can be obtained from nurseries that are tested and found to be free of many common strawberry pests, diseases, and viruses weeds are not a concern for transplant quality
- Contact nurseries early for greater availability of more vigorous transplants
- Develop good relations with preferred nurseries

Select transplants that have received adequate chilling and dormancy

- Transplants for fall/winter planting can begin production in low-elevation nurseries but should come from high-elevation nurseries where they can receive adequate chilling hours
- Transplants for spring/summer planting can be grown in low-elevation nurseries in late fall to early winter then held dormant in cold storage to achieve chilling until spring or summer. Transplants produced by this method are called refrigerated transplants.

Transplant Handling

- Keep transplants moist
- Place in wet soil
- Place within 7” of a drip line
- Place with roots extended downward
- Place so roots are below soil level and crown is above soil level
- Plant with good soil contact
- Irrigate immediately after planting
- Irrigate frequently to keep soil moist

Select planting dates that support vigor, timing and quality of fruit production

- Flower production increases when temperatures are low and days are short If planted early in the season, plants are less vigorous and many small fruit are produced rather than large fruit
- Vegetative production increases when temperatures are warmer and days are longer. If planted too late in the season, plants form runners rather than fruit so yield is delayed and reduced
- Recommended planting dates are specific to the type of variety and production area

Sanitation

- Rinse equipment before moving from one block to the next

© Photo by Terri Lajda, CRCD

Variety Selection

Strawberries are well suited to the mild climate of the California Central Coast. Varieties can be selected based on:

- Performance characteristics such as disease and pest resistance
- Fruit quality such as appearance, size, flavor and firmness
- Production occurring when market prices are high
- Potential for high yield

Types of Varieties

a Short Day Varieties

Short day varieties respond more to the influence of light than by temperature. Generally, short day varieties bloom when the days have less than 14 hours of light given that it is not too hot. These varieties tend to produce a few weeks before day-neutral varieties; however they cease to produce fruit from mid-June to August.

b Day-neutral Varieties

Since they are not influenced by light, day-neutral varieties have the capacity to bloom and produce fruit continually over the season, generally from May and in some cases until December. However these varieties cease to produce in high temperatures of 90 to 95 degrees Fahrenheit.

a Short Day Varieties

© Photos by Mark Bolda, UCCE

Benicia

This variety is similar to Ventana in planting dates and productivity. Fruit typically has a pink interior color and a very good taste, but fruit can be a bit dark in cases of extreme heat. Benicia has an open structure that facilitates harvesting. Benicia seems to experience a downturn in the later part of the harvest season but still performs better than many other varieties. It has some weaknesses to the soil borne pathogen *Verticillium*. High performance.

Camarosa

Camarosa was introduced more than twenty years ago in California quite successfully but it was overtaken by varieties such as Ventana and Benicia. The fruit is a bright red with good flavor. If the plant has too much vigor, it tends to be very large with much of the fruit is in the first part of the production cycle. Camarosa is slightly susceptible to soil diseases like *Phytophthora Verticillum* and also Powdery Mildew. Production Yield is regular.

Variety Selection

a Short Day Varieties

© Photos by Mark Bolda, UCCE
© Photo by Anne Coates, CRCD

Camino Real

Camino Real is a very productive variety with good flavor and a high tolerance to common pathogens. However, you should know that the fruit, which is used for processing and marketing, tends to be a bit darker than the other varieties. High performance in fruit production.

Chandler

A very old variety, Chandler is a favorite for direct marketing and home gardens. The fruit has a regular size, and a sweet flavor for a perfect balance. Production Yield is regular.

Mojave

This variety is planted earlier than Ventana and is typically more productive. Fruit size is consistent and has a bright red color. The fruit may not be as firm as other UC varieties but it can tolerate more rains. It is less tolerant to the soil borne pathogen ***Phytophthora***. Production Yield is regular.

Ventana

Ventana is similar to Camarosa in the beginning of fruit production, but the volume is higher in production. The plant is very productive in the first part of the year in southern California production areas. High performance.

Variety Selection

b Day-Neutral Varieties

© Photos by Terri Lajda, CRCD
© Photo by Carole Rowe, Sakuma Bros. Farms

Albion

Albion is generally known as the variety that replaced Diamante. The fruit comes in a shapely cone, with an exceptionally red interior. The flavor of this variety is lovely and many consumers think it has a better flavor than other varieties. The plant resembles Diamante, but is a bit more open and upright. Albion is more resistant to soil diseases such as Phytophthora and Verticillum, but it is known to be susceptible to Powdery Mildew. Albion tends to produce many runners that need to be cut periodically throughout the season. High performance.

Albion can continue to produce good size fruit and quality in a second year of production. To achieve another year of production from the same plant, the grower can prune the plants in the field in August, December or January to promote a new vegetative stage of the plant to produce what is known as second year berries.

Monterrey

A very popular variety of the Central Coast interior valleys, Monterrey is a strong and robust plant. Fruit is in a perfect cone shape with a bright red color. The fruit is pleasantly sweet. The fruit is slightly longer but less firm than the Albion variety. Less tolerant to *Phytophthora* and Powdery Mildew than the Albion variety. The Monterrey variety has good development and high potential yield.

San Andrés

The production of San Andres has a similar production to Albion, starting a few weeks earlier than Albion. The plant is a bit larger than Albion and the fruit is a lighter red than Albion. This variety might need less cooling than Albion. It has a better performance than most other varieties in production. High yield.

Seascape

Seascape is a favorite choice among producers of the organic strawberry industry due to its strong roots and relative ease of cultivation. Tolerance to *Verticillium* and *Phytophthora*, Powdery Mildew and some spider mites. Medium-sized fruit and a good flavor. Regular Yield.

Climate

Strawberries grow and perform better in maritime and Mediterranean areas of central and southern California. These areas enjoy relatively warm winters and relatively cool and dry summers. These conditions serve not only to promote formation of flowers and fruit, but also tend to mitigate challenges of disease and physiological problems.

Production areas of California's Central Coast

© Map from NASA, 2013

Most strawberry production in California occurs in three distinct regions, with some production occurring in outlying areas. For instance, in the Santa Maria Valley region, there are some strawberry growers a few miles north in Nipomo and Oceano. The three production areas are:

- Watsonville/Salinas
- Santa Maria Valley
- Oxnard/Ventura

The three principle areas of production of the Central Coast can be further divided into small sections referred to as "microclimates". Microclimates are cultivating regions with specific characteristics. It is good to be familiar with the characteristics of a new microclimate before cultivating to know the advantages, disadvantages, and considerations. For example, the development of strawberry varieties can be based on the climate and other characteristics.

Microclimates

Guadalupe Area

Most of the production area is located in and around the Oso Flaco area also known as Oso Flaco Lake. This area is located very close to the ocean so the marine influence dominates the area, resulting in very moderate temperatures. It is not subject to cold or hot temperatures during the growing seasons. Due to this geographic location, production starts and ends later compared to other areas. Production can extend into December depending on winter rain.

Sisquoc

This area is the furthest from marine influence and is known for wide differences between low and high temperatures. Historically the summer growing period can reach 90ºF with cool nights. These high temperatures translate into very early production. Since this area includes foothills, cool temperatures or frost in winter/spring are possible.

Climate

Tanglewood/The Winds (Los Vientos)

This area is located to the Southwest of the city of Santa Maria and is known in Spanish as "Los Vientos" because this is a location that is frequently windy. This production area includes fields adjacent to and in the vicinity of the Santa Maria Airport, and extends to the West side of Black Road. Usually production starts and concludes earlier than other areas because of moderating temperature differences influenced by the ocean.

East Betteravia

The Telephone Road-East Betteravia area is considered to be one of the most desirable growing areas in the greater Santa Maria region. Weather is still influenced by the ocean, but there are more significant differences between low and high temperatures compared to the other areas. Due to earlier warmer temperatures that initiate early production and close proximity to cooling facilities, this area has become an attractive location.

Important

Selecting the best site or location most importantly depends on the level of experience a grower has combined with the ability to manage production from different climatic areas.

Remember

Yield and fruit quality are greatly influenced by the photo-period, temperature, dormancy period, chill, as well as by disease, pests, and soil moisture fluctuations.

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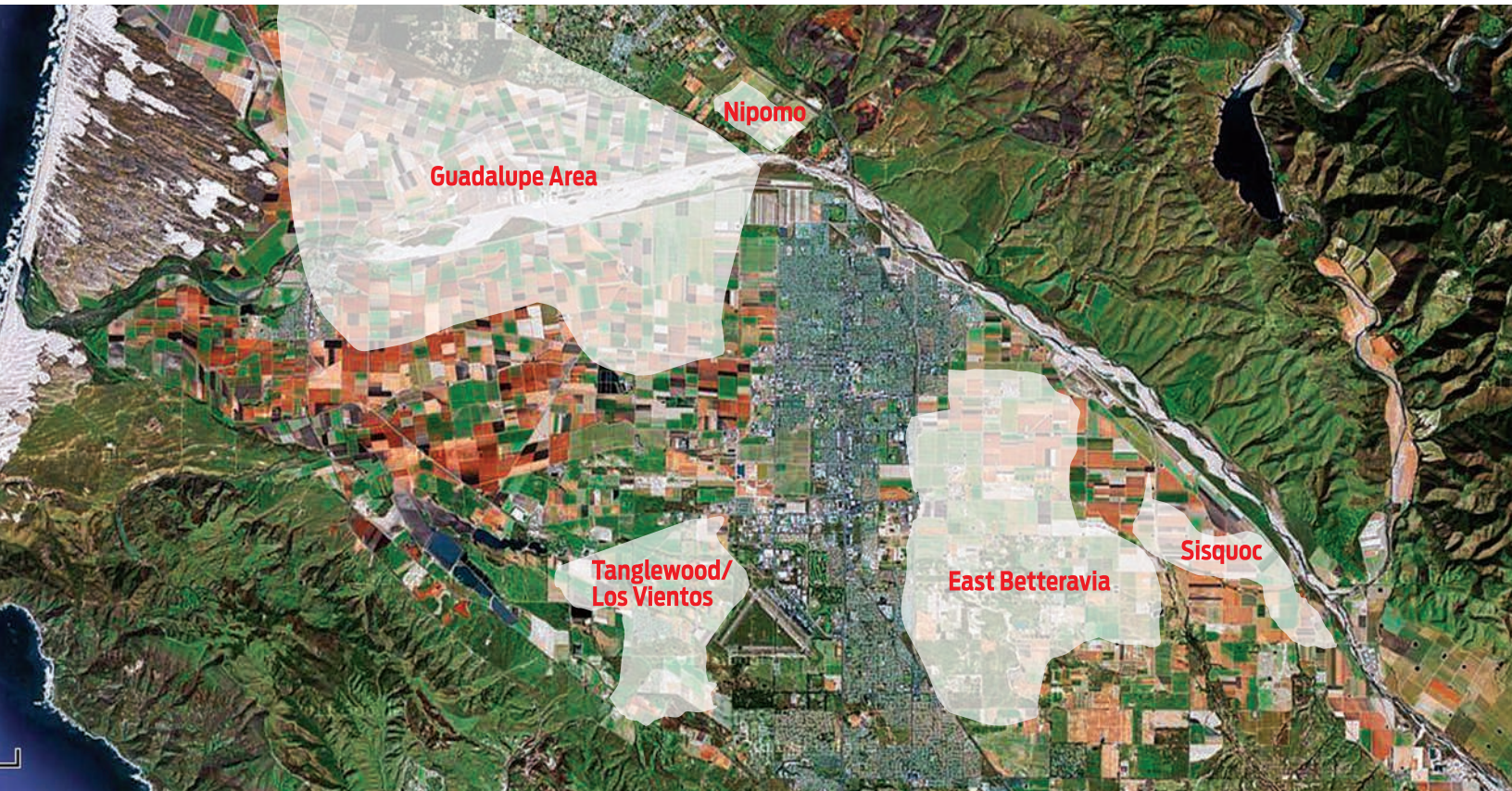


Seasons

Seasons

Fruit production is favored by moderate temperatures and low humidity.

Fruit production is usually timed for mid-spring with peak production being unique to each growing region, variety selection, and cultural production methods.

- Growth is promoted by temperatures above 50-degrees Fahrenheit.
- Both terms “Fall Planting” or “Winter Planting” are used for plants that produce in the spring and summer
- Both terms “Spring Planting” and “Summer Planting” are used for plants that produce fruit in the fall. These are also referred to as “cut backs”

Fall planting advantages:

- Early fruit for better market prices
- Often higher yield
- Better fruit quality
- Less costly

Summer Planting advantages:

- Can tolerate higher salinity (EC)
- Often less diseases
- Transplants can be dug directly from low elevation nurseries

Recommended Planting Dates

	Spring/Summer	Fall/Winter
Short Day Varieties		
Watsonville/Salinas		Oct 15-Oct 30
Santa Maria Valley		Oct 15-Nov 15
Ventura County		Sept 15-Oct 20
Day-Neutral Varieties		
Watsonville/Salinas		Nov 1-Nov 15
Santa Maria Valley	May 30-Jun 30	Nov 1-Nov 15
Ventura County	Jul 15-Jul 30	Sept 25-Oct 20

(Adapted from the UC IPM for Strawberries, Second Edition)

© Photos by Terri Lajda, CRCD

Planting beds

©

Fall planting

©

Soil Considerations

There are several Central Coast soil types, including Sandy, Sandy Loam, and Clay Loam. Each soil type has its own advantages and disadvantages. Many soils have less than 1% of organic material excluding the clayey soils which may have more than 3%.

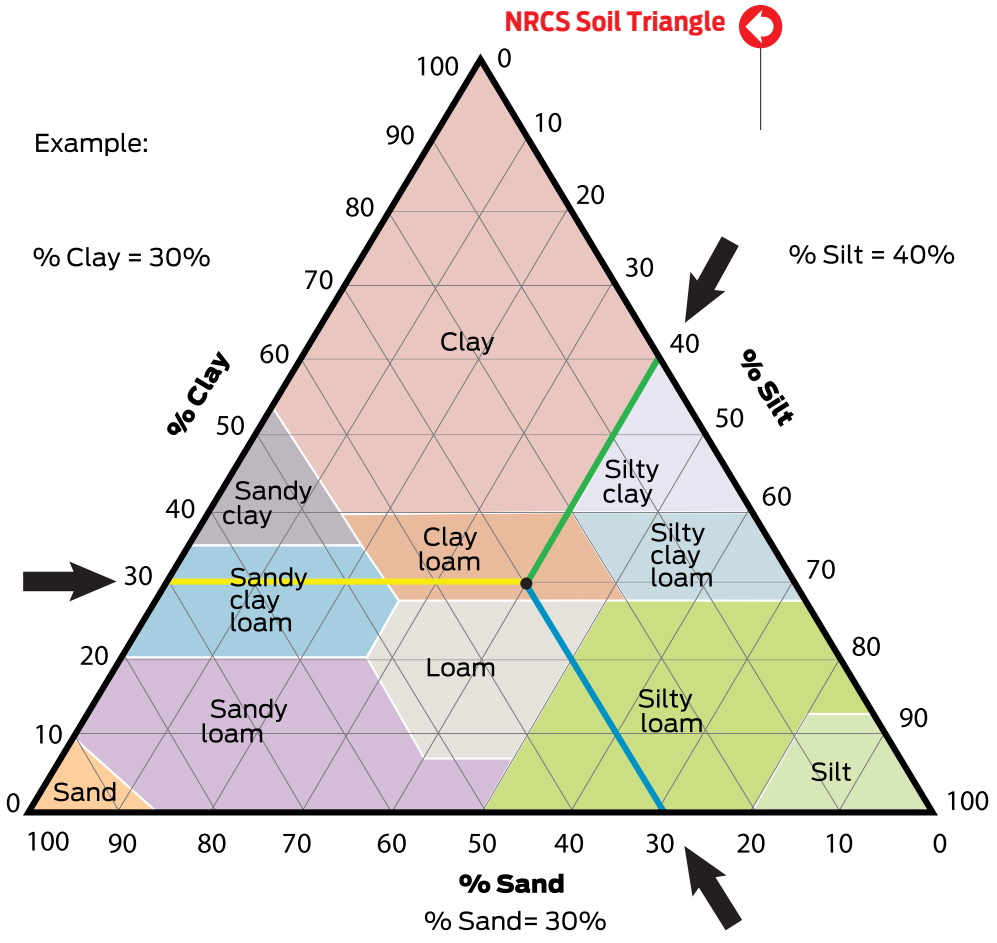
It is essential that growers know their soil type before planting strawberries.

Soil is composed of sand, silt, and clay. The percentage of each will determine the "soil texture" on the soil triangle. For example, soil with 30% clay, 40% silt, and 30% sand determines that this soil is silty clay on the soil triangle. As you dig in the ground, the texture changes.

The maps list the different soils by name and general texture. The detailed description of the soil includes the texture of the soil at different depths. For example, a soil sample from "Salinas silty clay" can have 2' of clay loam, then 1' of silt, and then 3' of silty sand below silt. The soil description also lists the pH, infiltration, and potential runoff.

Consider the following when selecting the field you would like to plant:

- Deep, well drained, sandy loam soils are preferred for strawberry production because field preparation is easier, fumigation is more effective, accumulation of salts is less likely, drainage is better, and the soil is better suited to the frequent irrigation and field activity that strawberries require
- The field should have good air drainage so cold air will not settle in the field
- Avoid poorly drained soils to minimize problems with root diseases such as Phytophthora (crown rot)



Important

Good drainage is essential to reduce the incidence of root disease problems and to keep salts from building up in the root zone. Rip the subsoil several times in different directions to ensure adequate drainage

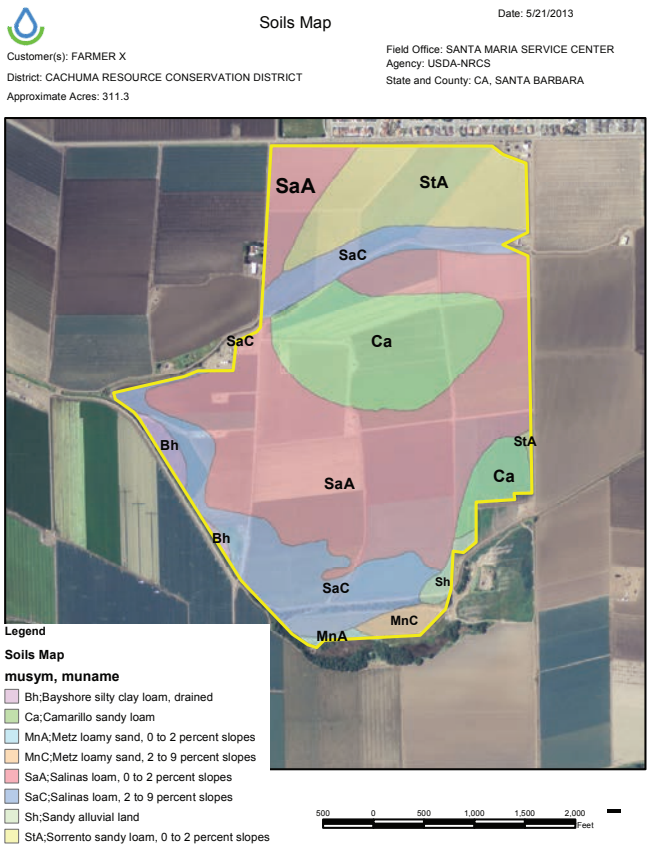
Land Preparation

Field Selection

The best land for strawberries is sandy loam to loam soil to allow drainage and still provide important organic matter levels. Heavier clay soils require higher beds to improve drainage. Blocks should be prepared with a slight slope to allow water to runoff so water will not collect in the field longer than 12 hours. Avoid low-lying sites where water drains slowly or cold air settles.

Strawberries do best where they do not follow a prior strawberry crop. On low organic matter soil (less than 1-2%), consider planting of a cover crop during spring and summer that is incorporated prior to land preparation for strawberries.

Soil Map



© Map by Emma Chow, NRCS

Soil Map

Obtain a soil map to better understand how to manage potential problems according to your soil type and soil profile. This can be achieved by visiting www.websoilsurvey.sc.egov.usda.gov or by talking to your local NRCS field office.

Soil Analysis

Before preparing your site for planting, collect field by field soil samples and send to a certified laboratory. With the soil analysis, the grower can determine pH, soil salinity (EC), organic matter, major and minor plant nutrient levels so appropriate amendments and nutrients can be added before planting to ensure optimal yield.

Soil Tillage & Preparation

Careful preparation of the field for pre-plant treatments and planting can have a great impact on the outcome of a successful production season. Important considerations include soil type, crop residue, bed design, and proper drainage. Fields with large amounts of residue should be prepared well in advance of fumigation and bed formation to allow residues to decompose. Soils should be cross plowed or “ripped” to a depth of 2.5-3 ft. Apply soil amendments according to recommendations from the soil analysis, then disc into the top soil. Following disking, the field can be bedded to prepare for fumigation and planting. Growers who lack experience with land preparation can contract this service from other growers or companies.

Erosion

Water and wind erosion are potential problems for strawberry fields depending on site topography, soil type, grading, road design, location, and historic wind conditions.

Water erosion primarily comes from runoff from plastic mulch, sloping furrows, and roads. A detailed drainage and erosion prevention plan should be developed when soil erosion is possible.

Field Preparation

Wind erosion is also common in the valleys of coastal production areas. It occurs during periods of high winds. Wind can transport soils particles onto the plants and fruit. Fabric fences or barriers offer some protection against the wind for all sizes of operations. Oats, barley, and other grain crops are often planted annually at the end of the rows to protect the nearby dry roads. Roads can also be moistened regularly to help with dust control.

Leaching (Pre-irrigation)

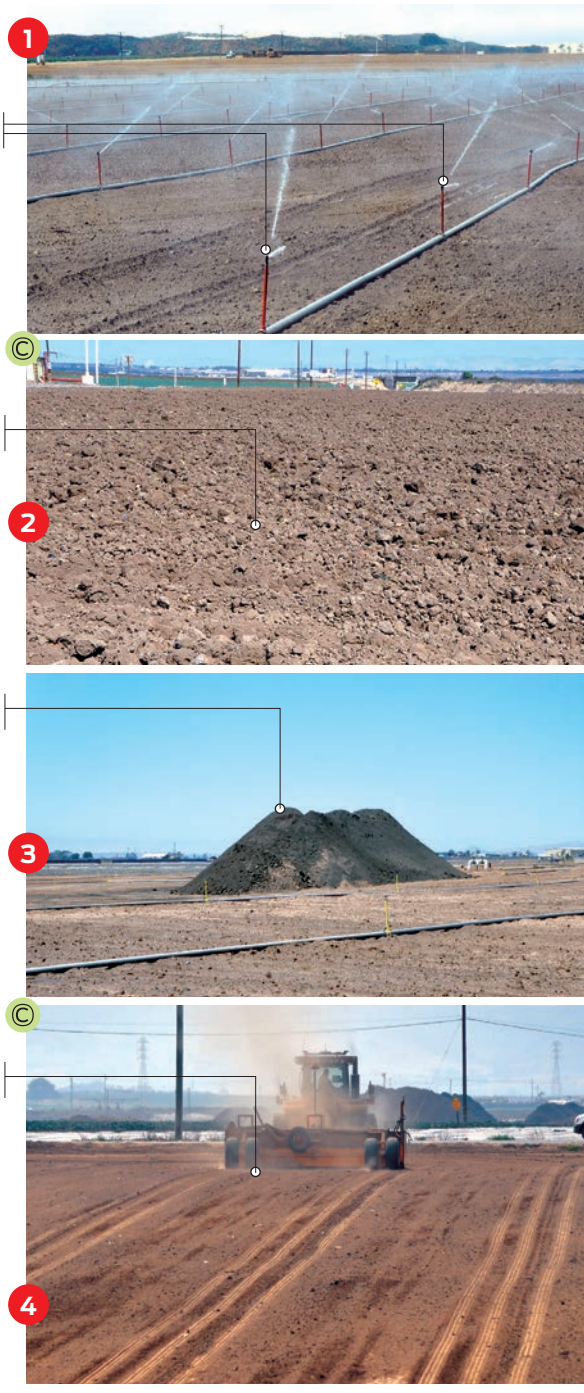
In fields where salt has built up in the soil surface from the prior cropping season, the salts can be leached below the root zone with sprinklers after the field has been worked. This procedure is performed after the field has been prepared. All field fumigation techniques and bed preparation benefit from a thorough pre-wetting. Coordinate pre-fumigation leaching irrigations with the fumigation contractor.

Fumigation

There are a number of fumigation products available as alternatives to the traditional methyl bromide which is being phased out. Fields must be uniformly wetted prior to fumigation. Fields may be broadcast fumigated over the whole level field or fumigation applied only to the bed via shanks or via the drip irrigation system. Fumigation must be done by a specially licensed company and growers should work with the applicator to plan additional permits and field procedures.

Fumigation

© Photo by Mark Bolda, UCCE



1 Leaching is also performed at the end of the process

2 Soil preparation

3 Incorporation of compost in the field prior to making the strawberry beds

4 Leveling off the field

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Plastic Mulch

Polyethylene (plastic) mulch selection depends on variety, planting area, harvest season(s), cultural practices, and other management factors.

Plastic mulch:

- Regulates soil temperature to influence timing of fruit development and maturity
- Protects flowers and fruit from soil and related disease problems
- Conserves soil moisture

Mulch is sold in many shades and colors including black, white, and green. In general, black absorbs heat while white reflects heat. Colors absorb less heat than black.

Light that is reflected by the mulch is reflected back onto the plant canopy. Mulch color can affect plant and fruit growth. Also, different mulch colors may attract different insect pests and beneficial insects.

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Mulch type and heat transfer

Mulch Type	Relative degree F difference compared to bare soil at 4" depth	Uses
Clear	6 to 9 degrees hotter	Early production
Black	3 degrees hotter	Weed control
White	0.7 degrees cooler	Summer planting; Delayed production

http://extension.psu.edu/plants/plasticulture/technologies/plastic-mulches

Plastic Mulch

The same color of mulch may be translucent to opaque depending on the manufacturer and type. It is important to know the opaqueness of the mulch. Opaque mulch is best for weed control. Plastic mulch types from clear to opaque:

- **Clear-** light passes through. Hottest soil; least weed control
- **Translucent (semi-transparent)-** some light passes through
- **Opaque-** light doesn't pass through. Best for weed control
- **Clear on top, Opaque on sides-** called "Skunk" or "Panda" is clear on top for heating soil and opaque on sides for weed suppression

"White-Solid" mulch top-side is white while the underside is black. This allows for both soil cooling and weed suppression.

Mulch and soil contact helps transfer temperature from the mulch to the soil. There is more potential to affect soil temperature with mulch when the mulch has good contact with the soil. When beds are prepared evenly, the mulch can be applied by stretching it for better heat transfer.

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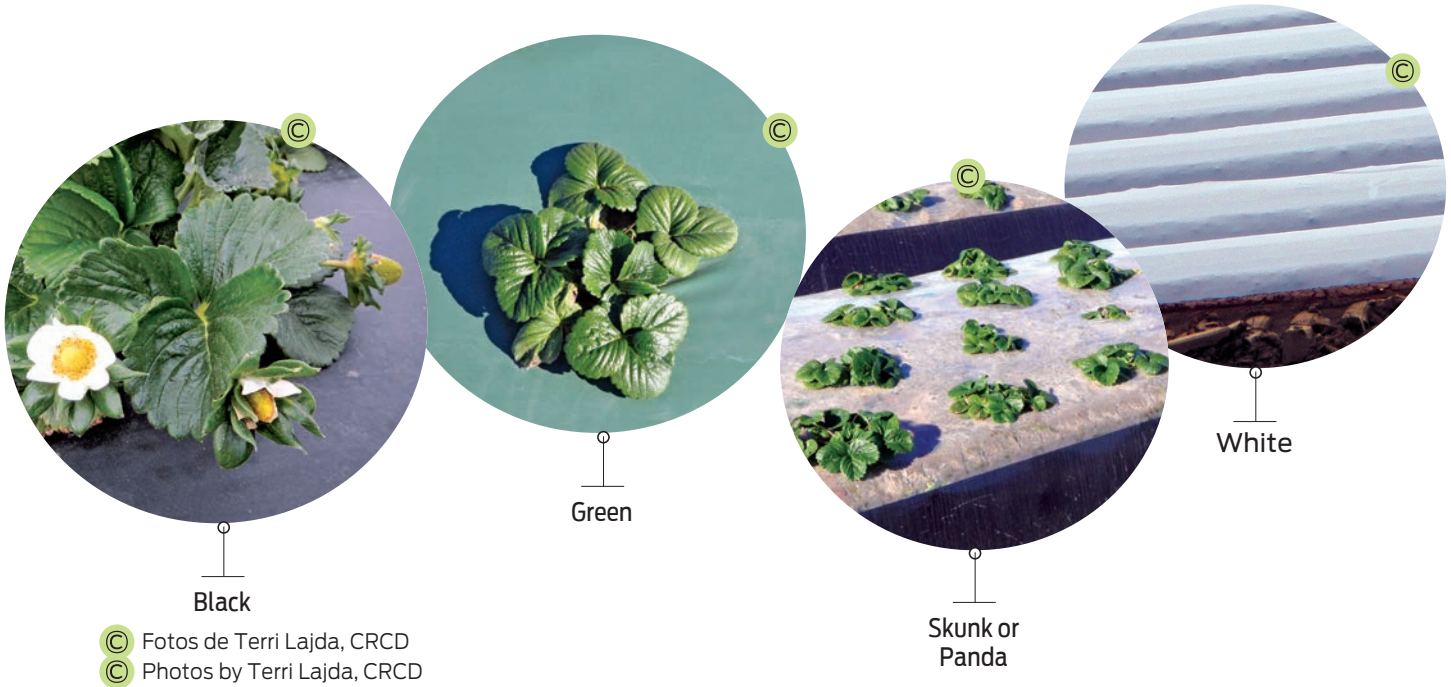
Different Mulch Colors



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Bed Designs

Bed design

1

2-row bed

2

3-bed row

3

4-bed row

The bed, plant row, and spacing decisions depend upon the variety, soil type, the time of planting, field topography, production season, and the grower's preference and experience.

Bed Design

Beds are normally formed by special machines using precision GPS tracking systems. Bed designs are important and can create several problems if not done correctly. For drainage purposes, higher beds are used in soils with higher clay content and soils that do not drain well. Irrigation design should be considered when designing beds.

Bed Rows

Typically strawberries are grown on raised beds with 2, 3, or 4 plant rows. The 4-plant rows can achieve the most plants per acre, typically 24,000 and 30,000 plants, while 2-plant rows may only achieve of 16,000 to 20,000 plants per acre. (reference: UC IPM for Strawberries p.18) This is because space is taken up by furrows. Furrow width depends on the equipment used to form the beds and is typically 10-14".

Plant Spacing

Spacing between plants generally varies from 10"- 16" and this spacing depends on the variety, soil type, growing area, etc. Center-to-center plant spacing is typically 60-68" for 4-row beds, 50-60" for 3-row beds, and 40-52" for 2-row beds. This spacing is measured from center-to-center of two adjacent beds.

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© Photo by Mark Bolda, UCCE

Bed Design

Plant Density

Plant density is determined by the spacing between plants, the bed width, and the distance between bed centers.

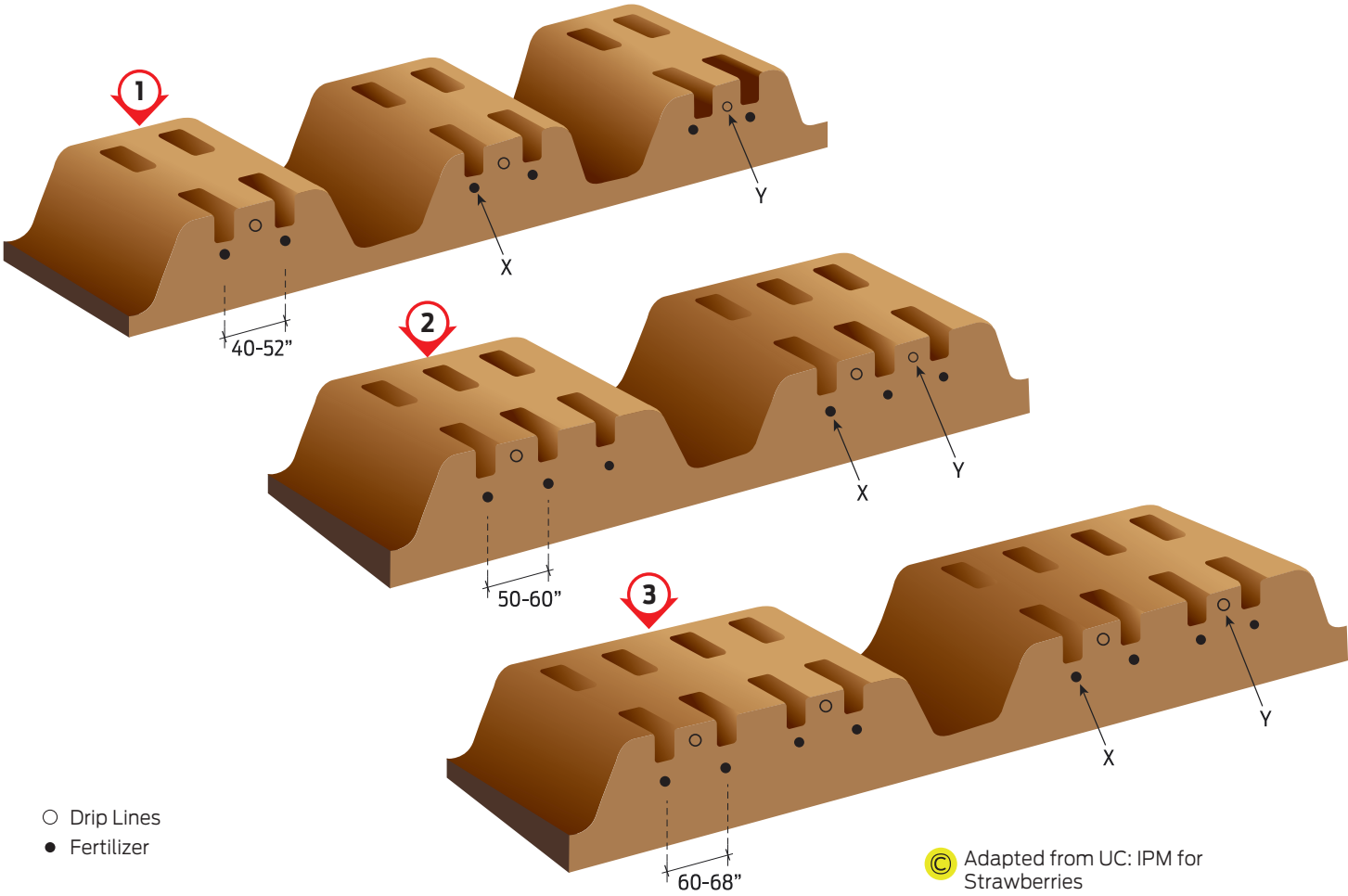
Caution

Planting at higher than optimum density can reduce fruit size and yield, increase disease, and cause picking to be more difficult. Lower then optimum plant density can reduce total fruit yield. It is advisable to work with the nurseries, UC Farm Advisors, and consultants to determine the optimum spacing for each location.

Important

Slow-release or phosphate monoammonium fertilizers can be placed 1" to 1.5" below the level of the plant roots (x) or below the drip line (y) next to roots. Fertilizer should be placed in a way that irrigation will move the nutrients into the root zone. The placement of fertilizers along the planting groove, to the side of the plants, reduces the risk of burns caused by fertilizers. The higher placement of fertilizers or broadcasting fertilizer onto the beds increases the probability of future salinity problems.

(Reference: UC IPM for Strawberries p. 18, 2008)



© Adapted from UC: IPM for Strawberries

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Row Orientation

Bed formation

Plant density

Topography

Topography
Slope may dictate row direction to capture sunlight most evenly.

Sunlight
For ideal sunlight on blocks with even topography, orient beds from north-to-south lengthwise because plants intercept sunlight more evenly. With east-to-west beds, the plants in the southern row on each bed receive more light, grow larger, and cause shading. The fruit produced on the plants of this row are also more subject to sunscald and fruit ripens unevenly.

Wind
When prevailing wind is strong and consistent it is best to orient rows across the wind to help slow down rapid drying that can occur when rows are oriented with the wind direction.

Reference
http://pubs.cas.psu.edu/freepubs/pdfs/AGRS097.pdf

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© Photo by CRCD

Planting

Planting dates should be planned in advance.

The Planting Date

There are two planting seasons for strawberries in California. Planting during the summer can be utilized for all growing areas; planting during the winter can be done in all areas except in the interior valleys. A successful planting during the winter requires a temperate climate to permit the production of the crown during the shortest days of the year. The best time to plant depends on the zone and variety.

Transplant and Nursery Selection

Every producer should be in contact with a reliable supplier, to acquire high performing, vigorous, pest-free transplants.

Be careful with the plantlets prior to planting

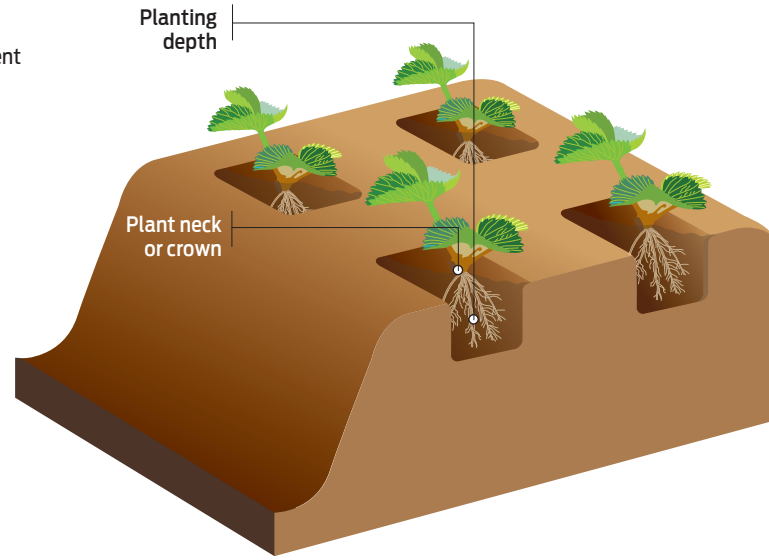
- Keep plants in a cool and humid place on the field during the transplanting
- Thoroughly wet the fields prior to planting and place the plants in moist soil
- It is important to plant the plants carefully and at the correct depth, with the crown on the surface of the soil at a depth of 6-7 inches (not too deep, not too shallow). The roots may be pruned before transplanting no more than 4 inches from the base of the stem. Do not allow the roots to fold over in the planting hole

First Irrigation

Irrigation immediately after planting is the best way to establish the transplants. Irrigation can prevent developing plants from being damaged by salinity and drought. To ensure growth and optimal performance requires frequent watering to maintain a moist root zone, especially during the first 4 weeks after planting.

Plant establishment

Planting team



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Roads

Roads are one of the most vulnerable areas on the farm for erosion. With a few simple techniques, your roads can be protected.

Important Areas

Uphill: Look at runoff sources from uphill of the farm. Redirect these flows to a sediment basin or to a well protected road.

Non-cropped areas: Plant a cover crop or perennial grasses on bare soil.

Low spots: Look at the natural low spots in the field and place roads there. Low spots with lots of water should have a grassed channel next to it.

Furrows: Slow down storm runoff by creating long furrow blocks with 1-3% slopes.

Downhill: Slow down concentrated water by planting dense vegetation at the base of the hill or capturing it in a sediment basin.

Don't Forget the Furrow Blocks: Furrows and plastic mulch on beds concentrate and speed up run off of winter rains.

Remember

Concentrated runoff that comes from hoop houses (tunnels) is a potential source of erosion from rain water.

© Photo by NRCS

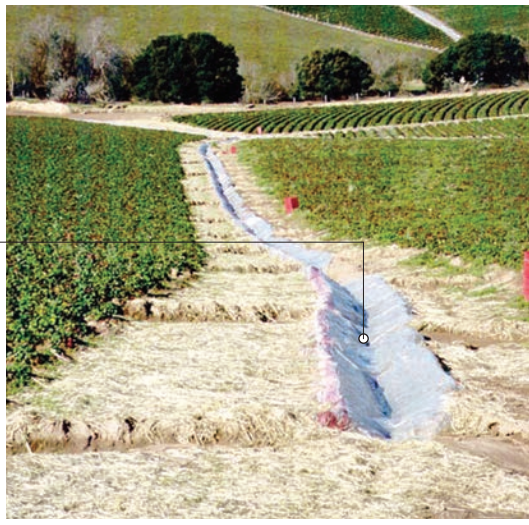
© Photo by Misael Sanchez, CRCD

© Photo by Oleg Daugovich, UCCE

Roads

Methods for shaping a road with a low spot in the center:

1. Cultivate fields and chisel if necessary to increase water infiltration
2. Cut roads with scraper to form a gentle "V" shape, 6" deep in the center
3. Spread soil in low parts of field
4. Line beds across roads
5. Cut roads again with scraper to form a gentle "V" shape, 6" deep in the center
6. Use leftover soil to make water bars or shape beds; don't leave soil on the roads
7. Roads at edge of farm can be sloped toward natural vegetation

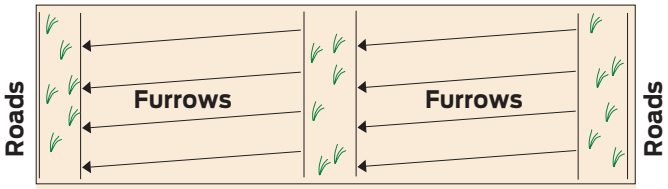


Road with a low spot in the center. Due to the steep slope, the center is covered by plastic.

© Photo by RCDMC

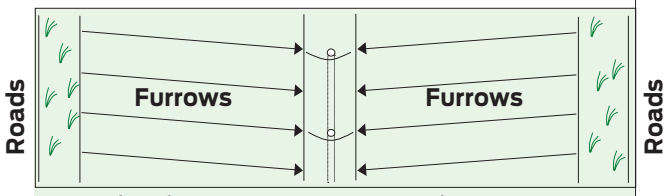
Control water before it impacts the roads

Divide and Control



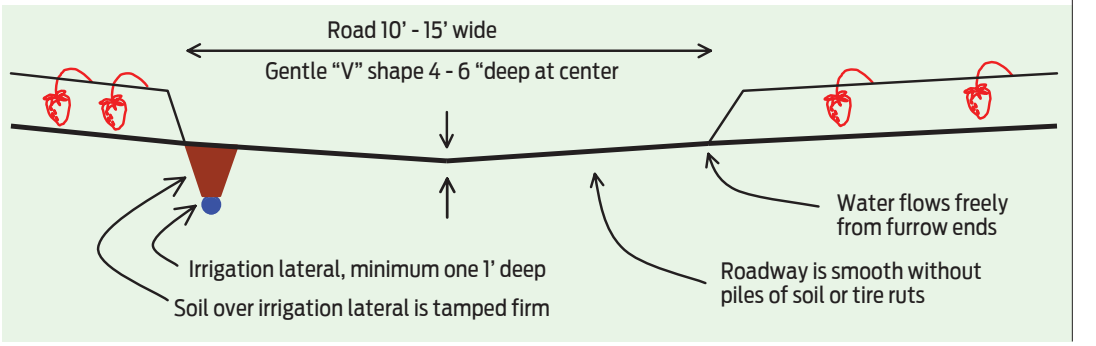
For roads with minimum protection; grass or grass and ditches covered in plastic

Concentrate and Control



For roads with strong protection; grass and a system of underground pipes

Leveling of Roads: looking above the road



Grass Planting

Rye, fescue, and barley seedlings showing root and plant growth

Excavator

Ribbed roller

Sowing

Plant grass at the end of bed rows and over the roads to control erosion

Fall Grass Planting to Minimize Winter Erosion

Why is grass on winter roads important?

1. Provides a large root mass that protects roads from washing out
2. Protects bed ends from slumping
3. Inhibits the growth of weeds
4. Enhances the water quality of lowland streams

Should I use Annual or Perennial Grasses?

Annual Grasses	Perennial Grasses
▪ Quick to establish in the fall ▪ Do not need a nurse crop ▪ Require little maintenance	▪ Suited for permanent roads & critical areas ▪ Slow to establish in the fall ▪ Need a nurse crop for first year establishment ▪ Require weed maintenance for first two years
▪ Short roots	▪ Deep roots
▪ Need to replant every year	▪ Provide cover & protection through the years
▪ Protect soil in winter	▪ Reduce dust in summer/protects soil in winter

© Photos by RCDMC

© Photo by Julie Fallon, CRCD

Grass Planting

Methods for grass road seeding

1. Plant grasses as soon as roads are cut and irrigate if necessary
2. If soil on road is compacted, lightly aerate the soil with a disk, chisel or a rake (Passing over the soil with a ring shank roller prepares an excellent seed bed)
3. Broadcast seed over the road by hand or with a seed broadcaster. If you were to throw a baseball cap over the seeds, you should see ten seeds below the hat
4. Seed more heavily around ends of beds and seed 10 feet into each furrow
5. Lightly bury seed about 1/2 inch deep in soil by passing over it with a disk or rake
6. Cover the seed with straw mulch to protect it and retain moisture
7. Provide supplemental irrigation if planted before rains
8. Mow grass before seeds set

Tip

Use these tables as a guide to planting grass on the top portion of the road that can drain safely and then begin the ditch or pipeline part way down your road with grass. If you think that there is a large amount of water that comes from non-cropped areas, you will be safer to extend the ditch or pipe all the way up the road.

Completely seeded road with straw mulch

© Photo by RCDMC

Maximum number of acres that roads with grass can protect

Do you use full bed plastic mulch?
Established Annual or Established Perennial grass?

Full Bed Plastic, Annual Grass (such as barley)

Road Slope	Acres
4%	2 1/2
8%	1
16%	1/3
24%	1/4

Full Bed Plastic, Perennial Grass (such as creeping wild rye)

Road Slope	Acres
4%	5
8%	3
16%	2/3
24%	1/2

Do you NOT use full bed plastic mulch?
Established Annual or Established Perennial grass?

No Plastic, Annual Grass (such as barley)

Road Slope	Acres
4%	6 1/2
8%	2 1/2
16%	3/4
24%	1/2

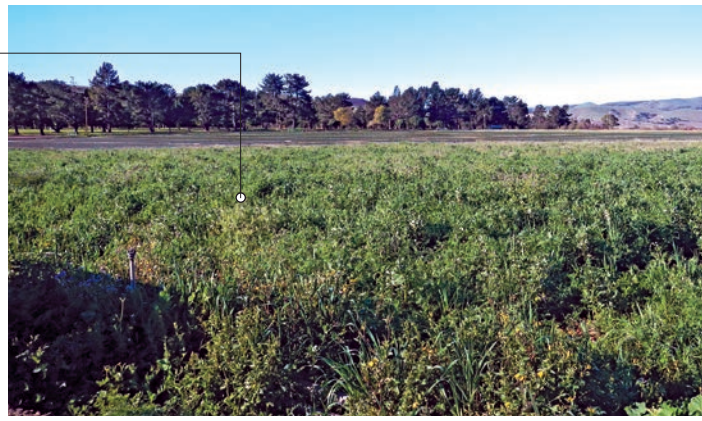
No Plastic, Perennial Grass (such as creeping wild rye)

Road Slope	Acres
4%	13
8%	5
16%	1 1/2
24%	1

Road Stabilization

Are grass and the design of the road the only things necessary to maintain your roads?

Look at the figure below to find the maximum number of farmed acres that can be safely drained with grass alone to stop road erosion.



© Photo by Julie Fallon, CRCD

Suggested Grasses, Seeding Rates, and Timing

Seed Varieties	Life Cycle & Planting Time	Grass Characteristics	Pounds of seed per 100 feet by 10 feet of roadway	Pounds of seed per acre	Established per cost per acre for seed
Cereal Rye "Merced" Variety *Secale cereal* *Don't confuse cereal rye with annual rye that is an invasive weed	▪ Annual ▪ Early season ▪ Sept – Nov	Good on dry, sandy slopes, excellent roots	2 lb/acre	80	$24/acre
Common Barley "UC 63" Variety *Hordeum vulgare*	▪ Annual ▪ Late season ▪ Nov and Dec or for emergencies	Good on all soils, fair roots	4.5 lb/acre	180	$23/acre
Trios "102"	▪ Annual ▪ Early season ▪ Sept – Nov	Good on all soils, good roots and low growth pattern	1.5 lb/acre	60	$25/acre
California Brome *Bromus carinatus* (Nurse crop, indicates fast germination rate, short lived - 3 years)	▪ Perennial ▪ Native Mix ▪ Early season	Good on dry, sandy slopes Creeping wild rye (slow germination rate, long lived 100 years) Good roots and good on dry, sandy slopes and loamy/clay soils, excellent roots	.3 lb/acre & 12 lb/acre	12 & 12	$180/acre & $240/acre

Ditches and Pipes

Plastic Lined Ditches & Grass to Protect Steep Roads from Erosion

Methods for installing a plastic lined ditch:

1. After roads are cut and smoothed, cut 1' deep x 4' wide ditch in center of the road
2. Lay out 2 mil embossed plastic or 6 mil plastic for maximum strength. Both can withstand a deer stepping on them without tearing. Do not reuse fumigation plastic
3. Start at the bottom of the hill and work your way up
4. When you start the second sheet of plastic, make sure it overlaps the first sheet by about 2 feet
5. Dig a small trench (6' deep) along the outer edge of plastic. Tuck edges into the trench and bury
6. Plant grass on the road above and on the sides of the ditch and 10 feet into the furrows
7. Use rocks or willows at the bottom of the slope to minimize damage from water flow

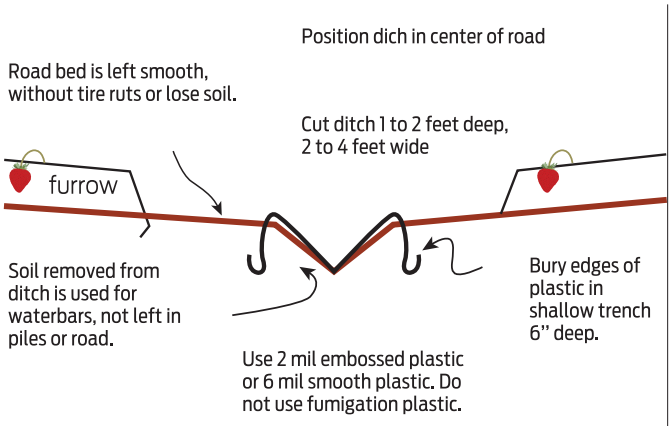
Underground Pipes & Grass for Permanent Erosion Control

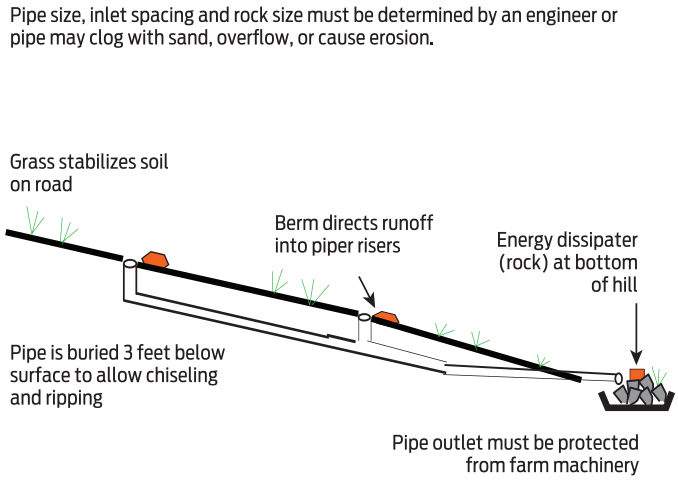
What is the benefit of underground pipes?

Storm water that reaches your farm roads can be directed into an underground pipe and transferred down the slope without taking sediment and crops along with it. The sediment and concentrated water that does wash down the slope are caught in a sediment basin. The water slowly filters out and the sediment is collected so that it can be brought back up the slope the next year. This system is a permanent and highly effective solution. You need to designate critical low roads to be the permanent pipe location and work with an engineer to size pipes and design a sediment basin.

Warning

Using underground pipe without a sediment basin at the bottom can cause gullies and/or flooding.





Irrigation Fundamentals

The purpose of irrigation is to replace soil moisture lost from the root zone due to plant use and evaporation. The plant roots extract water stored in the soil each day. At the same time, solar radiation causes moisture evaporation from the soil surface. The amount of irrigation water required by the plant increases with rising temperature, windy conditions, longer day length, and plant maturity.

Strawberry plants require consistent moisture throughout the growing season, especially when they are developing to maturity. Transplanted plants are generally overhead irrigated daily using sprinklers for up to six weeks to get good initial vegetative growth. Newly developing roots are sensitive to dryness and salinity, so careful placement of fertilizer and frequent irrigation is needed to prevent reductions in growth and yield. The irrigation is then switched over to drip irrigation as the season progresses. Drip irrigation keeps the moisture away from the fruit and prevents fruit rot.

Irrigation Methods

The following three irrigation methods can be used for strawberry production systems. Sometimes multiple methods are used on the same crop for different purposes throughout the season.

Under Irrigation

When there is a shortage of water in the root zone, the following can occur to cause yield/quality losses:

- Reduced flower production
- Premature flower and fruit drop and vegetation death
- Poor utilization of soil nutrients which can increase susceptibility to pests and disease damage, and decrease fruiting

Over Irrigation

When plants are watered too long or too frequently, the following can occur to cause yield/quality losses:

- Reduced flower production
- Wet conditions favor some pathogens
- Leaching of nutrients from the root zone causing nutrient imbalances and deficiencies that decrease fruiting

© Photo by Julie Fallon, CRCD

Irrig ation Methods

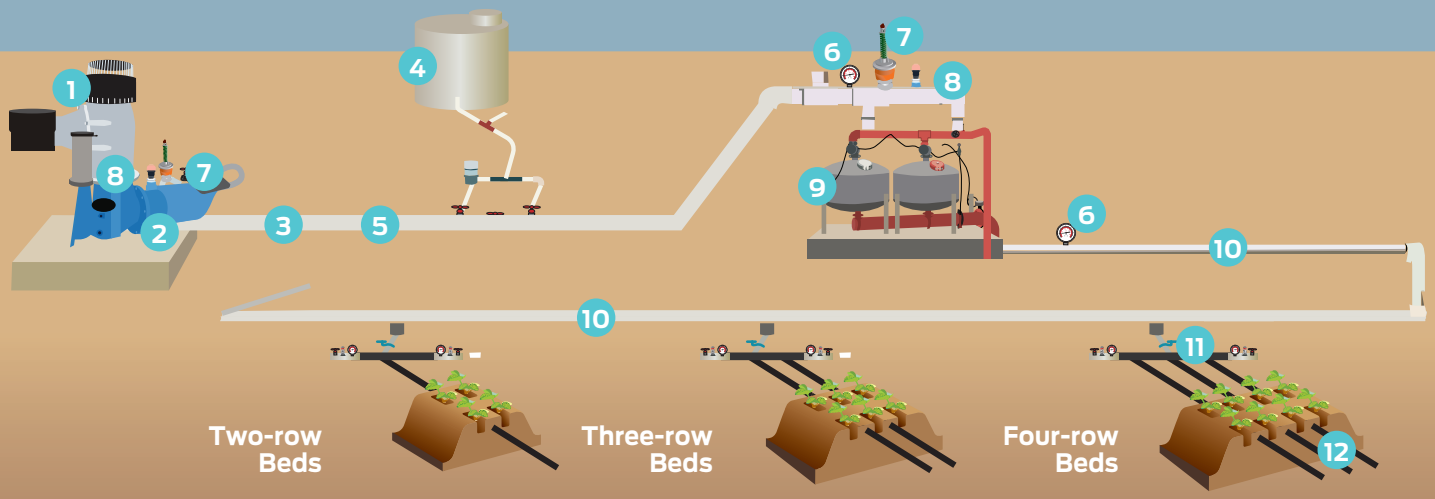
	Sprinkler	Microsprinkler*	Drip
Field preparation	●		
Plant establishment	●	●	●
Fruit production stage			●
Frost protection	●		
Salinity control	●	●	●

*Microsprinklers are often used in tunnels and hoop houses

Want assistance?

For assistance with scheduling, for a mobile lab irrigation system evaluation, for assistance with runoff and erosion, and to see if cost-share funding is available contact your local RCD, NRCS, and UCCE (see technical assistance page for more information).

System Design



1 Pump
Pressurizes & moves water through the irrigation system

2 Backflow Devices
Prevents fertilizers & other injected chemicals from flowing backwards into a well or other water source

3 Flow meter
Measures the amount of water pumped into the irrigation system

4 Fertilizer tank
Safely stores required plant nutrients (closed system) until they are injected into the irrigation water

5 Injection systems
Adds fertilizers & other chemicals into the irrigation system

6 Pressure gauges
Used to monitor the operating pressure at critical points in the irrigation system

7 Pressure Safety Valves
Protects the irrigation system and pipes against damage due to high pressure

8 Air/vacuum release valve
Releases air and vacuum within the piping network

9 Sand media filter
Removes particles that can clog drip emitters

10 Main line & sub-main lines
Usually PVC pipe or a layflat hose that delivers water to the lateral drip lines

11 Pressure regulating valve (PRV)
Regulates/adjusts delivery pressure downstream of the PRV and helps maintain constant system pressure

12 Drip tape
Discharges water through small channels (emitters) spaced at regular intervals along the plant row

Drip Irrigation

Features:

Low flow systems utilizing buried and surface pipes, hoses, and tape
- Usually a low pressure system using small pumps (25 psi)
- Emitters are manufactured inside tape and hose or added externally

Advantages:
- Potential for high irrigation efficiency (80 to 90%) and distribution uniformity (DU)
- Reduced volume of water required
- Direct application of moisture in the soil root zone
- Fertilizer and chemicals can economically and efficiently be applied
- Lower pumping costs

Disadvantages:
- Higher design and installation cost
- Requires clean water. Emitters can be plugged by solids in the water
- Needs skilled operators for maintenance, repairs, and system operation

Parts of the system

The drip irrigation system has three parts or areas:

1. Pump, fertilizer injector, and filter station
2. Main and sub main pipelines
3. Laterals with emitters

Pumps

The size of the field and the flow capacity of the pump system are very important. Pump performance can vary depending on seasonal water table changes and will be reduced gradually due to wear.

Determine the flow or discharge rate and pressure out of the pump. This is accomplished by:
- Using previous pump test data
- Conducting a pump test using pump manufacturer performance curves

Adjust the system design, field size and emitter flow rate to match the pump capabilities

Filters

Irrigation water is filtered to reduce emitter plugging. Drip emitters have small passageways that can become plugged with both inorganic particles (sands, silts, clays and chemical precipitates) and organic particles (algae, bacteria, and bacterial by-products). Different types of filters are available to address different plugging concerns.

Screen filters are most common and are usually constructed of stainless steel, nylon, or polyester. This type of filter is well suited for inorganic particles. The screen mesh (20 to 200) can be selected depending on the size of particles in the water and the orifice of the emitter.

Disk filters, like screen filters, are suitable for filtering well water without sand particles. If sand is present, then a special sand separator is inserted before the main filters. This type of filter has a large filtering surface area. Many disks are stacked tightly together resulting in grooves that filter the particles.

Sand media filters remove a greater range of particle sizes than screen and disk filters. They filter both organic and inorganic particles and can be used with both ground and surface water. Contaminant particles are filtered as the water flows through sand (media) for cleaning.

Drip Irrigation

Main lines and sub-mains

These deliver water from the pump to individual field beds and are usually made of PVC plastic, polyethylene, or aluminum. The correct size depends on the system flow rate.

The design takes into consideration the cost of piping and pressure loss through the system.

Emitters

Emitters supply water to the beds and can be installed on or below the surface of the soil. There are many manufacturers of drip emitters and drip tape. Among the most important factors affecting system performance are emitter type, discharge rate, and spacing; tape diameter and wall thick-ness. Other important factors that should be considered are cost and quality.

Discharge rate is measured in gallons per minute per unit of tape length (100 feet). The discharge rate is important to consider in designing a drip system so that the application rate of irrigation water can closely match the crop water use. Drip tape is generally manufactured as low, medium, or high flow discharges.

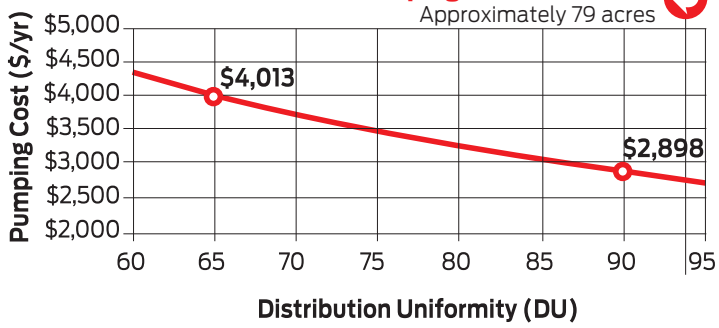
Drip Tape Discharge Rates

High-Flow	> 0.5 gallons per minute per 100 feet of tape
Medium-Flow	< 0.5 and > 0.3 gallons per minute per 100 feet of tape
Low-Flow	< 0.3 gallons per minute per 100 feet of tape

© Photo by Terri Lajda, CRCD

Pumping Costs versus DU

Approximately 79 acres



(By Mark Barnett, NRCS)

For More Information contact your local Natural Resource Conservation Service (NRCS) and Resource Conservation District (RCD)

Sprinkler Irrigation

Features

- High flow rate system with large pumps and water source
- High pressure (50 psi) system utilizing large motors and pumps. Often, booster pumps are required to transport water and to elevate pressure to that required for sprinkler operation
- Above ground pipes carrying water to the field are usually aluminum. Aluminum lateral pipes are placed in the furrow between beds
- Utilizes risers with rotating sprinkler heads evenly spaced up and down the delivery lateral

Advantages:

- Covers 100 percent of the soil surface for leaching and bed preparation
- Large volumes of water can be applied in a short period of time
- System is temporary and can be removed from the field
- Water impact helps with soil root contact after transplanting
- Does not require very clean irrigation water

Disadvantages:

- Labor intensive for setup, moves, and operation
- High energy cost
- High system pressure required
- High flow rate increases potential for runoff and erosion
- Potential for waste and runoff of water applied to mulch and bed rows
- Creates environment favorable for weeds and pathogens
- Wind reduces distribution uniformity

Important

Start filter flushing when pressure readings in and out of the filters differ 5 to 10 PSI.

Caution

- The amount of water distributed by the sprinkler must be less than the rate of infiltration to avoid runoff and soil erosion
- Depending on the water source, a screen filter may be required to prevent sprinkler nozzle clogging

Water before you begin planting

© Photos by Terri Lajda, CRCD

System Maintenance

To ensure the proper function and durability of the materials and equipment, the following are recommended and can be performed while performing leak repair:

1 Check and Clean Tape or Hoses

- Verify that all tape and/or manifolds and sub mains are properly located on the beds and are not leaking
- To flush the system, open the end of the hoses or tapes while the system is running. Flush one tape or hose at a time in order to have sufficient pressure

2 Check and Clean Emitters

- When the irrigation water contains salts that could clog emitters, acids can be used to drop the pH to 6.5 to avoid carbonate precipitation

3 Check and Clean Filter

- Visually Inspect before each irrigation. Clean by washing with pressurized water or soft plastic brush (for example, a tooth brush). Never use steel brushes, wires, or objects that may damage the filter
- If the filter is broken or the screen is damaged, it should be replaced immediately

4 Check System Pressure Gauges

- Gauges should be installed on the inlet and outlet side of the filter to monitor operating pressures. An inlet pressure increase and outlet pressure decrease indicates filter plugging

5 Control Algae

- To prevent algae growth within the system, inject bleach (chlorine) with the water as a solution into the system until detected out the farthest line (use a swimming pool chlorine tester)

Injection rate gal/hr = 0.03 x GPM divided by % chlorine

Example: The desired initial chlorine concentration in irrigation water just past the point of injection is 5 ppm. Assume a drip irrigation system with a total flow-rate of 100 gallons per minute (gpm) and that common chlorine bleach (5.25% chlorine) will be injected.

Injection rate = 0.03 x GPM divided by % chlorine
= 0.03 x 100 divided by 5.25
= 0.57 gal/hr

© Photo by Misael Sanchez, CRCD

© Photo by Terri Lajda, CRCD

Salinity Management

Strawberry plants are very sensitive to salinity (salts). Salts, especially sodium (Na) and chloride (Cl), are problematic because they make it hard for strawberry plant roots to extract soil water. Salts come from the following sources:

- Irrigation water
- Fertilizer
- Soil amendments
- Soil parent material

Analysis of Salinity

- High salt levels in the irrigation water can cause transplants to die and cause reductions in strawberry size and yield
- Electrical Conductivity in the irrigation water (Ecw) is measured in dS/m
- Measuring the Ecw of the irrigation water can be performed using a laboratory or with a field meter

Methods of Control

Salts can build up in the root zone over the growing season. Salt build up (salinity) in the soil must be managed within the tolerance level for the strawberry plant.

- The primary method of managing salinity in the soil is to leach salts out of the root zone
- Leaching takes place when water from rain and/or irrigation events passes through the soil root zone
- Leaching also takes place when irrigation water is applied in excess of the crop water requirement. This is called using a 'Leaching Fraction'

The Leaching Fraction (LF) is the percent of the total applied water that should be leached to avoid yield losses

- When irrigation water dS/m is less than 1.0, excess salts can be leached out of the root zone. When irrigation water dS/m is 1.2, there can be a 10-25% reduction in yield

http://www.itrc.org/reports/strawberries.htm

Important:

- When leaching salts, fertilizer will also be leached, so only leach when necessary
- Remember that rains also leach salt

© Photos by Oleg Daugovich, UCCE

Irrigation scheduling

Basic Steps to Plan and Complete an Irrigation Event

STEP 1

Determine Irrigation Frequency

Irrigation Frequency
The amount of time between irrigation events.

Irrigation frequency is determined by the amount or rate of crop water use in relation to the water available in the soil. Crop water use is affected by size of the plants and weather conditions The larger the plant, combined with hot, dry, and windy weather conditions, the greater the water uptake. Young plants need less water but also need to be irrigated more frequently than mature plants because they have shallow roots and will dry out more quickly.

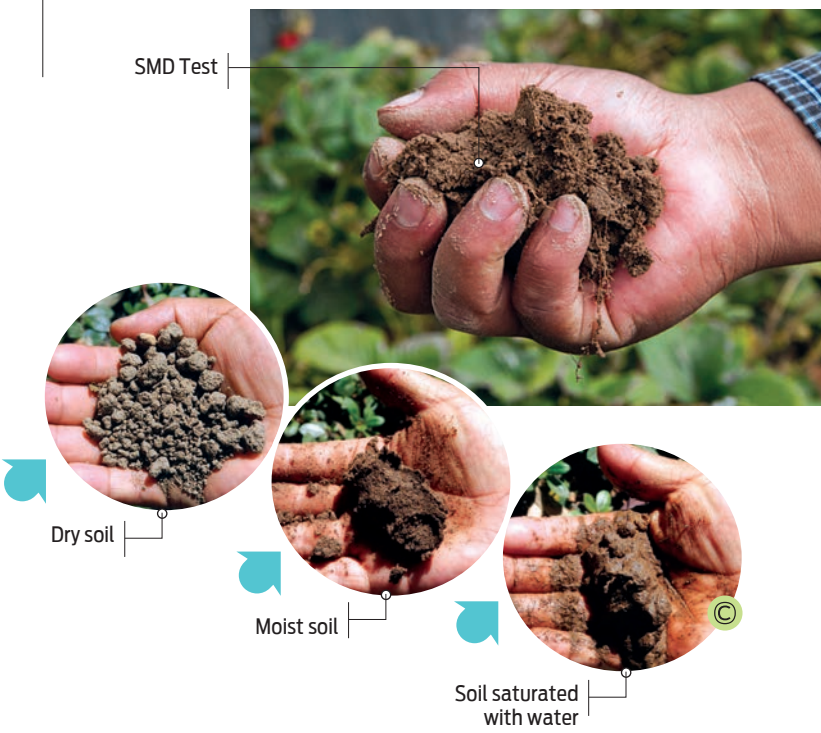
Plants extract soil water at a rate measured in inches per day. The water stored in the soil is measured by inches of water per inch of soil depth. Strawberry plants extract water out of the soil up to a set amount, termed the Managed Allowable Deficit (MAD). Once this level is reached an irrigation event is required.

STEP 2

Determine Soil Moisture Depletion (SMD)

The amount of water to be replenished since the last irrigation is the SMD.
SMD can be determined using these methods:

- Estimate the SMD in the effective root zone using the USDA field moisture determination chart/guide
- Determine evapotranspiration (ET) water loss since last irrigation. Plant growth curves and/or % canopy cover can be used to determine crop ET (ETc) at different growth stages as the plants develop to maturity. At maturity, strawberries have an ETc of 0.85



© Photos by Terri Lajda, CRCD

Irrigation scheduling

Using USDA guide to determine SMD and soil moisture

Available Water Capacity in inches per foot when the feel and appearance of the soil are as described.

	Fine Sand and Loamy Fine Sand	Sandy Loam and Fine Loamy Sand	Sandy Clay Loam and Clay	Clay, Clay Loam, or Silty Clay Loam
Available Soil Moisture 50-75%	Moist, forms a weak ball. Loose and aggregated sand grains remain on fingers, darkened water staining 0.2 - 0.6 (in/ft)	Moist, forms a ball with few aggregated soil grains breaking away. Light water staining, darkened color 0.3-0.9 (in/ft)	Moist, forms a firm ball with well-defined finger marks, irregular soil/ water coating on fingers. Darkened color and pliable 0.4-1.1 (in/ft)	Moist, forms a smooth ball with defined finger marks, little or no granules remain on fingers. Pliable, ribbons between thumb and forefinger 0.4-1.2 (in/ft)
Available Soil Moisture 75-100%	Wet, forms a weak ball, loose and aggregated sand grains form uneven coating on fingers 0.0-0.3 (in/ft)	Wet, forms ball, free water appears on soil surface when squeezed or shaken. Irregular soil/ water coating on fingers 0.0 -0.4 (in/ft)	Wet, forms ball, free water appears on soil surface when squeezed or shaken. Irregular soil/ water coating on fingers 0.0 - 0.5 (in/ft)	Wet, forms soft ball soil may glisten following squeezing or shaking, light to heavy soil/ water coating on fingers, easily ribbons 0.0 - 0.6 (in/ft)
Available Soil Moisture 100%	**Wet, forms a weak ball. Free water glistens briefly on surface when shaken. Wet outline on hand after squeezing** **0.0 (in/ft)**	Wet, forms a soft ball, free water appears briefly on soil surface when squeezed or shaken. Irregular soil/ water coating on fingers 0.0 (in/ft)	Wet, forms soft soil pat with water glistening on surface after squeezing or shaking. Thick soil coating on fingers 0.0 (in/ft)	Wet, forms very soft soil pat. Thick soil/ water coating on fingers. Soil glistens slick and sticky, will not ribbon 0.0 (in/ft)

Adapted from USDA booklet, NRCS "Estimating soil moisture through feel and appearance."

Irrigation scheduling

STEP 3

Determine the Application Rate (AR) of the System

- The AR is the depth of water applied to a given area per hour by the irrigation system, usually measured in inches per hour
- If an AR is 0.2 inches/hour that means every hour that the system is run is equivalent to an average of 0.2 inch rainfall

Sprinkler Application Rate

Use Table for approximate application rate or use application rate provided by mobile lab irrigation report.

Sample water application rates [inches/hour]

Sprinkler PSI	Spacing	Nozzle Diameter 3/32	7/64
40	30x35	0.15	0.20
50	30x35	0.17	0.22
55	30x35	0.18	0.20

© Photo by Terri Lajda, CRCD

Drip Application Rate

Use Table for approximate application rate or use application rate provided by mobile lab irrigation report.

Use bed width to determine application rate

Bed Width [inches]	Tape Discharge Rate [gallons/min. per 100ft]				
	0.30	0.35	0.40	0.45	0.50
24	0.14	0.17	0.19	0.22	0.24
28	0.12	0.14	0.17	0.19	0.21
32	0.11	0.13	0.14	0.16	0.18
36	0.10	0.11	0.13	0.14	0.16
40	0.09	0.10	0.12	0.13	0.14
44	0.08	0.09	0.11	0.12	0.13
48	0.07	0.08	0.10	0.11	0.12
52	0.07	0.08	0.09	0.10	0.11
56	0.06	0.07	0.08	0.09	0.10
60	0.06	0.07	0.08	0.09	0.10
64	0.05	0.06	0.07	0.08	0.09
68	0.05	0.06	0.07	0.08	
72	0.05	0.06	0.06	0.07	0.08
76	0.05	0.05	0.06	0.07	0.08

Adapted from Drip Irrigation for Row Crops

Remember

Multiply the application rate by the number of drip lines to get the application rate per bed.

Irrigation scheduling

STEP 4

Determine the Irrigation Runtime

Adjust for Distribution Uniformity (DU)

More water needs to be applied when the irrigation water is not being distributed evenly so that the plants receiving the least water will still receive sufficient water. Irrigation systems are not 100% efficient in distributing water. When a system is designed and maintained optimally:

- Sprinkler irrigation can typically achieve 75% (0.75) DU
- Drip irrigation can typically achieve 85% (0.85) DU

DU is lower when there is not enough pressure, uneven pressures, plugging, leaks, and other design and maintenance issues.

Use approximate DU or use DU provided by mobile lab irrigation report.

More DU → Less Water Applied → Less pump waste

$$\text{Runtime} = \frac{\text{Soil Moisture Depletion (SMD)}}{\text{Application Rate x Distribution Uniformity (AR x DU)}}$$

For example, if SMD is 0.2 inches, the application rate is 0.11 inches, and the DU is 0.60

$$\text{Runtime} = \frac{0.2}{(0.11 \times 0.60)} = 3.03 \text{ hours}$$

Runtime = 0.2 divided by 0.066

Runtime = 3 hours

What if the DU was higher? What if it was 0.80?

$$\text{Runtime} = \frac{0.2}{(0.11 \times 0.80)} = 2.27 \text{ hours}$$

Runtime = 0.2 / 0.088

Runtime = 2.27 hours (about 2 hours and 15-minutes, rather than 3 hours)

When the DU is higher, runtimes can be reduced. Improved DUs save water and pumping costs and keep fertilizer in the root zone.

Irrigation scheduling

STEP 5

Make Adjustments for Leaching Fraction (LF)

If applying a LF, use the table to determine additional water to apply as the LF

	Approximate LF			
ECw (dS/m)	0.25	0.50	0.75	1.00
% LF	5%	15%	20%	25%

For example, a runtime of 2.75 hours with a 5% LF would run 5% longer

2.75 x 1.05 = 2.89 or about 3 hours rather than 2.75 hours

For example, a runtime of 2.75 hours with a 25% LF would run 25% longer

2.75 x 1.25 = 3.43 or about 3.5 hours rather than 2.75 hours

STEP 6

Perform Irrigation

Recommendations:

1. Have an irrigation evaluation performed
2. Determine leaching fraction
3. Make upgrades based on the report to improve the DU
4. Have the system checked after upgrades are made so Runtimes can be determined using accurate AR and DU numbers

Wind reduces sprinkler DU so schedule sprinkler irrigations to avoid wind.

Monitor for runoff and erosion, especially on slopes. Some soil types do not infiltrate as quickly as water can be applied using sprinklers. The system can be redesigned to apply water more slowly or water can be run in split applications.

Important:

When calculating the Irrigation Duration in Step 2 (as shown below), make sure to add "1" to the Leaching Fraction before finishing your calculation.

Example

	Step 1		Step 2: 5% Leaching Fraction (LF)
Irrigation Duration =	**SMD /** Page 46	**(AR x DU)** Page 47	**Irrigation Duration = x (1 + LF)** Page 49
Irrigation Duration =	0.2 /	0.11 x 0.80	2.27 x (1 + 0.05)
Irrigation Duration =	0.2 /	0.088	2.27 x 1.05
Irrigation Duration =	2.27 Hours		2.38 Hours

Notes

	Step 1		Step 2: Leaching Fraction (LF)
Irrigation Duration =	**SMD /** Page 46	**(AR x DU)** Page 47	**Irrigation Duration = x (1 + LF)** Page 49
Irrigation Duration =	_____ /	_____ x _____	_____ x (1 + _____)
Irrigation Duration =	_____	_____	_____ x _____
Irrigation Duration =	_____ Hours		_____ Hours

Nutrients

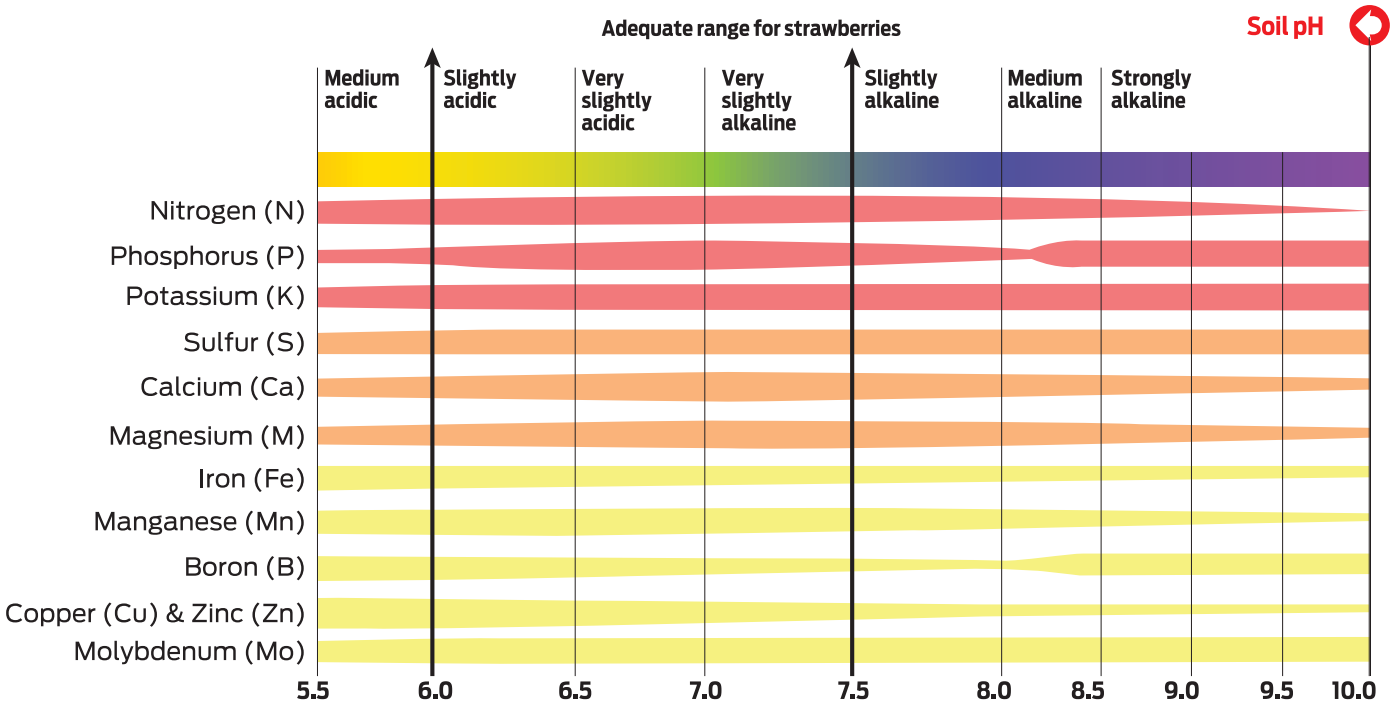
For optimal performance, quality, and development, the strawberry plant needs 17 essential nutrients in amounts that change over the season based on the stages of development and weather.

Nutrient balance is important (the right amounts of each nutrient in relation to other nutrients) and nutrient management is challenging for many reasons:

- Nutrient deficiencies and toxicities often can't be easily diagnosed by looking at plants because different problems cause similar symptoms
- Excess amounts of some nutrients can cause problems in plant health and yield (for example, favoring vegetative growth vs. flowering)
- Some nutrients in the soil are bound in forms that are not readily available to the plant. To meet plant needs, nutrients must be mobile (typically in dissolved forms in soil water), but mobile nutrients can also leach via "deep percolation" below the root zone where plants cannot reach them

A soil lab report will provide the soil pH; soils may be acidic (pH <7) or alkaline (pH >7). Alkaline soils may also be called basic. Nutrient availability can change with pH. Soil pH may be altered deliberately, for example by adding lime. It may also be altered as a result of other management practices, for example by application of ammonium fertilizers that have an acidifying effect on the soil pH.

Macronutrients and micronutrients are available for plants to adequately absorb within a range of 6.0-7.0 pH.



Macronutrients

© Photos by Albert Ulrich, UC Statewide IPM Program

© UC Statewide IPM Program

Nitrogen | N

Nitrogen makes up 2.4 to 3.0 percent of a mature strawberry plant and has various functions within the plant. Nitrogen is an essential part of amino acids that form all proteins in the world and directs many metabolic activities of the plant. Furthermore, nitrogen makes up a good portion of genetic material that directs all plant activities. Nitrogen is also a constituent of the plant cell wall.

Because nitrogen forms a part of the chlorophyll molecule, a lack of it would manifest itself as a yellow color on the leaf and general chlorotic condition of the plant.

Nitrogen is utilized by the plant in two major ways. In the strawberry, the nitrogen is most consumed by a mature plant; meanwhile ammonia is understood as being consumed during cooler seasons and weather. It is important to understand that there is a nitrogen cycle in the soil. Nitrogen that comes from organic material from the soil, such as residue from other crops or plants, is first converted to ammonia then to nitrogen. Nitrogen doesn't last long in the soil before it is washed from the root zone due to leaching.

Phosphorus | P

Phosphorus, like nitrogen, is an important constituent of the plant and normally makes up a percentage from 0.3-0.4. Like nitrogen, phosphorus is almost ubiquitous in the plant and has an important role in the formation of various enzymes, proteins, and genetic material. Because it is important for genetic material, phosphorus is important for the reproductive life of the plant and, to some degree, promotes the early maturity and quality of the fruit.

Potassium | K

Potassium makes up about 1.3 to 1.8 percent of a mature plant and plays a big role in the water management of the plant. It is required to create firmness within the plant, and so the plant can maintain its osmotic power of the cells. Potassium regulates the opening and closing of the cells surrounding the stomata of the leaves. Potassium is involved in extracting water from the soil, retaining water in plant tissue, and transporting water large distances within the plant. Potassium also functions as a regulator of pH within cells.

Potassium is important in the growth of cells. Walls that have sufficient potassium tend to have a suitable thickness and this increases resistance to physical harm, diseases, and insects. From this, it can be said that fruit from a plant with suitable potassium levels has a good probability of withstanding more time in the market.

Calcium | Ca

Calcium is an important constituent of each of the cell walls of the plant and must constitute 1.0 – 2.2 percent of a mature plant. Calcium also regulates the structural stability of these walls and the permeability of the membranes.

Magnesium | Mg

Magnesium plays an important role in the chlorophyll molecule. Therefore, a lack of magnesium will result in a chlorotic condition (like nitrogen) that progresses to eventually cause burns on leaf margins. Normally, a magnesium deficiency is defined as below 0.1 percent, and a healthy strawberry plant should have between 0.28 to 0.42 percent magnesium in their tissues.

Sulfur | S

Two essential amino acids that are important to the formation of proteins in the plant contain sulfur. Sulfur should be within 0.15 to 0.21 percent ranges in the tissues of a healthy strawberry plant. Sulfur also has an important role in various hormones and vitamins of the plant.

Micronutrients

Iron | Fe
Iron, like magnesium and nitrogen, is an important part of chlorophyll. Because this element is not mobile within the plant, a lack of iron is manifested by new leaves turning yellow. Once this condition intensifies, the space between the veins on the leaf can turn white. A strawberry plant should normally have a concentration of 85 to 200 ppm (parts per million) of iron in its tissues.

Zinc | Zn
Zinc is another mineral that displays its deficiency through a yellowing of the leaves. However, this yellowing leaves the margins green and this condition persists with the age of the leaf. Zinc is an important component in various enzymes in the plant and in the formation of proteins. Zinc should be in a range between 15 to 28 ppm in healthy tissues of the plant.

Manganese | Mn
Manganese plays a role in photosynthesis and is a component in various enzyme systems. Manganese has a wide concentration range within plant, tissues of a healthy plant, between 75 to 600 ppm.

Boron | B
Although Boron is essential in many plant functions such as transport of sugars through cell membranes and cell wall synthesis, it does not need to exist in high concentrations in the strawberry plant. Normally, to accomplish a healthy and strong plant, concentrations of boron should be within 10 to 100 ppm.

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Fertilizers

Types of Fertilizers

Nutrients are the plant food utilized to form roots, branches, leaves, flowers, and fruits. The quantity and availability of nutrients influence the fertility of the soil and plant. Fertilizers come in a liquid or solid form.

a Solid (Dry) Fertilizers

Fertilizer granules are normally incorporated into the soil before planting. Application rates are determined based on soil analysis. Detailed studies have indicated that newly planted strawberry plants use little nitrogen before the end of February in California strawberry production. Some powder fertilizers (soluble) can be injected into the irrigation system.

- Fertilizer granules are normally incorporated into the soil before planting
- Application rates are determined based on soil analysis, crop need, and soil factors

b Liquid (Fluid) Fertilizers

- Liquid fertilizers are commonly used in-season because they can be easily and efficiently injected into micro-irrigation systems or applied as a foliar spray
- Some water soluble fertilizer materials may be applied in a liquid form directly to the crop foliage. Foliar fertilization is often used for application of micronutrients. For maximum nutrient uptake, a conical spray nozzle should be used to completely wet the plant foliage with fertilizer solution

c Organic Fertilizers

- Nutrients may be applied using a variety of non-synthetic fertilizer materials, for example manure, composted manure, bone meal, dried blood, fish emulsion, etc.
- Often, nutrient levels in these materials are low relative to levels in synthetic fertilizers, and nutrients may not be immediately mobile for quick plant uptake. However, these materials may improve other soil properties, for example, nutrient and water holding capacity. They may also release nutrients over a longer period of time.

d Other Nutrient Sources

There are other sources of nitrogen that, if significant, need to be accounted for in the nutrient budget. These nutrient sources contain organic matter to improve soil structure, improve soil habitat for beneficial soil microbes, and release nutrients slowly over time. Consult with a Farm Advisor or other Technical Service Provider (TSP) for assistance in calculating N-P-K from these sources.

- Compost
- Crop residue or biomass from the previous crop
- Cover Cropping - if leguminous, releases nitrogen or if incorporated into soil becomes “green manure”

Fertilizer Storage and Mixing

- Maintain all fertilizer storage facilities to meet government and industry standards and protect them from the weather
- Maintain proper calibration of fertilizer application equipment and ensure solution backflow does not occur
- It is safer to use a backflow prevention device with interval air technology more commonly known as “air gap”
- Check for compatibility before combining fertilizers or fertilizers or before combining them with other chemicals. Combining some liquid fertilizers can cause precipitates that clog the drip emitters

Fertilizer Application Methods

Soil Fertilization: Fertilizer is added directly to the soil in granular or liquid form.
Fertigation: Fertilizer is dissolved in water and applied through the irrigation system.
Foliar Fertilization: Fertilizer is dissolved in water and applied directly to crop foliage.

Fertilizer Calculations

Solid Fertilizers

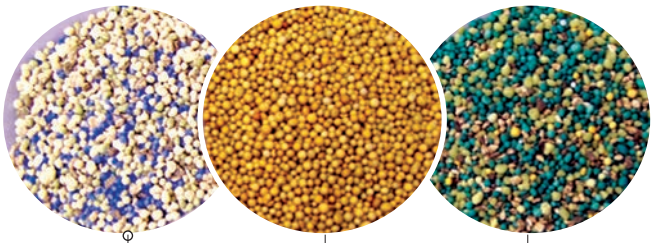
Sometimes fertilizer recommendations and guidelines are given in the oxide form (e.g. P_2O_5 or K_2O) and sometimes as the element (e.g. P, K). If you need to know the element form, first convert the value on the label from the oxide form to the element form:

N = Nitrogen	P = Phosphorus	K = Potassium
N = lbs N (no conversion)	P_2O_5 x 0.44 = lbs P	K_2O x 0.83 = lbs K

For example, if a fertilizer bag shows a guaranteed analysis of 19-6-13, this means the fertilizer is 19% N, 6% P_2O_5 y 13% K_2O by weight. Remember, in Step 1, you have to convert the percentage to a decimal before multiplying it. So, 10% = 0.10, 15% = 0.15, 20% = 0.20, etc.

In Step 2, you account for the fact that only a fraction of the P_2O_5 and K_2O are P and K.

© Photo by Terri Lajda, CRCD



Examples of solid fertilizers
Photo by Tim Hartz, UC Davis

Step 1	Step 2
(19%) 0.19 N x 50 lbs = 9.5 lbs N	**9.5 lbs N**
(6%) 0.06 P_2O_5 x 50 lbs = 3 lbs P_2O_5	3 x 0.44 = **1.3 lbs P**
(13%) 0.13 K_2O x 50 lbs = 6.5 lbs K_2O	6.5 x 0.83 = **5.4 lbs K**

You can do these conversions with any fertilizer analysis and any amount of fertilizer by the following:

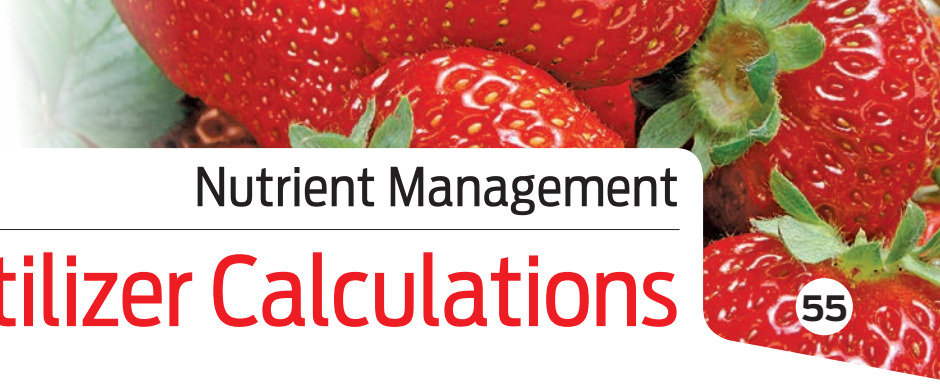
Lbs of fertilizer x % N = lbs of N
Lbs of fertilizer x % P_2O_5 = lbs P_2O_5→ lbs P_2O_5 x 0.44 = lbs of P
Lbs of fertilizer x % K_2O = lbs K_2Olbs K_2O x 0.83 = lbs of K

Notes:

_____ % N x _____ lbs = _____ lbs N

_____ % P_2O_5 x _____ lbs = _____ lbs P_2O_5 x _____ lbs N
_____ x 0.44 = _____ lbs P

_____ % K_2O x _____ lbs = _____ lbs K_2O
_____ x 0.83 = _____ lbs K



Fertilizer Calculations

Liquid Fertilizers

Liquid fertilizers must be converted to gallons first.

The label of the liquid fertilizer should list the density in lbs per gallon. The value can be used to convert the guaranteed analysis on the label to lbs fertilizer then to lbs of N, P, and K applied.

How many pounds of N-P-K in 100 gal of **5-10-10** liquid fertilizer, with a density of 11.65 lbs/gal?

First, convert the liquid volume to a mass (pounds applied):

100 gallons x 11.65 lbs/gallon = 1,165 lbs of fertilizer

Second, do your calculations as shown below:

1,165 lbs of fertilizer x 0.05 (remember this is the 5%) = 58.25 lbs of N

1,165 lbs of fertilizer x 0.10 = 116.5 lbs P_2O_5 → 116.5 x 0.44 = 51.3 lbs of P

1,165 lbs of fertilizer x 0.10 = 116.5 lbs K_2O → 116.5 x 0.83 = 96.7 lbs of K

100 gal x 11.65 lbs/gal = 1,165 lbs	
5% N x 1,165 lbs = 58.25 lbs N	58.3 lbs N
10% P_2O_5 x 1,165 lbs = 116.5 lbs P_2O_5	116.5 x 0.44 = 51.3 lbs P
10% K_2O x 1,165 lbs = 116.5 lbs K_2O	116.5 x 0.83 = 96.7 lbs K

Notes:

_____ Gal x _____ lbs/gal= _____ lbs of fertilizer

_____ % N x _____ lbs = _____ lbs N

_____ % P_2O_5 x _____ lbs = _____ lbs P_2O_5

_____ % K_2O x _____ lbs = _____ lbs K_2O

_____ lbs N

_____ x 0.44 = _____ lbs P

_____ x 0.83 = _____ lbs K

Nutrient Budgeting

Recordkeeping

- Perform ongoing recordkeeping on each field of water and nutrient inputs. Maps and photos as "photo documentation" are very useful to include. Get maps from NRCS or RCD
- Keeping detailed records can help you understand crop response to fertilizer and water inputs, and help fine tune your nutrient and irrigation water management decisions. Over time, this can help you maximize yield and crop quality and save money.

Develop a nutrient budget:

1. Know typical amounts of nutrients that your strawberry variety requires for optimal production
2. Determine what nutrients are available in the soil and/or added in fertilizer, other soil amendments or irrigation water
3. Review information and determine appropriate management steps

STEP 1

Nutrients Required

Typical nutrient uptake is listed below. Expected nutrient uptake should be estimated for each field after considering all the factors that may influence nutrient uptake, including expected yield, soil conditions, pest and disease pressure, water availability, plant variety, weather factors, etc.

Total seasonal uptake at Watsonville and Santa Maria California (Adapted from Hartz, Bolda, Gaskell, and Bottoms, 2012. UC Water Quality Pub.)

Nitrogen	180-220 lbs/acre
Phosphorus	90-110 lbs/acre
Potassium	270-330 lbs/acre

Total N uptake during early growth (Planting through March)	Average daily N uptake during active growth (April through August)
At least 20 lbs/acre**	1 lbs/day/acre

In addition to knowing total seasonal uptake, it's important to know when in the growing cycle the nutrients are needed in what amounts.

Estimated seasonal nitrogen (N) uptake for strawberry crops in Watsonville and Santa Maria California* (Adapted from Hartz, Bolda, Gaskell, and Bottoms, 2012. UC Water Quality Pub.)
*Growing conditions in Oxnard/Ventura promote active growth and nutrient uptake earlier in the season compared to Watsonville and Santa Maria. There is likely less nutrient uptake overall in southern Oxnard/Ventura because the growing season is typically shorter than in Watsonville and Santa Maria production areas.

** Quantity is being investigated

- Record anticipated nutrients required numbers into your Nutrient Budget Planning Sheet

© Photo byTerri Lajda, CRCD

Nutrient Budgeting

STEP 2

Nutrients in Soil and Water

Soil

- Use Laboratory Tests for important soil information: soil fertility and guidelines, pH, Ec (salt) level, Sodium (Na) ppm, organic matter (OM) %
- Have a Technical Service Provider (TSP) help you interpret the test. RCDs may be able to translate the analysis into Spanish for you or your employees

Water

- Have an RCD or Coalition staff member perform a "mobile lab" test of the irrigation water for nitrogen content (ppm N) or use a SNQT test strip to test water. Know that N levels in well water may change over the season. Test periodically
- Record the amount of nutrients in the soil and water into your Nutrient Budget Planning Sheet

STEP 3

Determine and Record Need

Decide when and how much fertilizer you are likely to need
Check which value your test results (for soil or water) report nitrate (NO_3) or nitrate nitrogen (NO_3-N). Nitrate (NO_3) represents the whole molecule, including O_3, meanwhile nitrogen NO_3-N represents only the value of nitrogen. Choose the appropriate conversion factor:

Conversion Factors in Soil:

When You Know	Multiply By	To Find
ppm NO_3-N	2	lbs N/acre (6 inch sample)
ppm NO_3-N	4	lbs N/acre (12 inch sample)
ppm NO_3	0.45	lbs N/acre (6 inch sample)
ppm NO_3	0.90	lbs N/acre (12 inch sample)

Conversion Factors in Water:

When You Know	Multiply By	To Find
ppm NO_3	0.23	ppm NO_3-N
ppm NO_3-N	4.43	ppm NO_3

(Taken from "Fertilizer Management in Coastal Cool-Season Vegetables" Fact Sheets that Monterey County Water Resources Agency developed using the University of California Division of Agriculture and Natural Resources publication "Production Guide: Nitrogen and Water Management for Coastal Cool-Season Vegetables")

Nutrient Budgeting

Calculating amount of N applied in irrigation

Step 1

Water content in ppm NO_3	x 0.052	= pounds of N/acre per inch

For example, 100 ppm NO_3 x 0.52 = 5.2 pounds of N/acre per inch.

Step 2

Pounds of N/acre per inch	x Inches of ET of crop	x Irrigation Efficiency	= pounds of N/acre applied in the irrigation water

- Evapotranspiration (ET) of crop: Inches of irrigation water taken in by strawberries – possibly between 20 – 29 inches
- Include the leaching factor due to salinity
- Irrigation efficiency is related to Distribution Uniformity (DU) and appropriate scheduling

For example, 5.2 (pounds/acre per inch) x 20 (inches of ET of crop) x 0.70 (Irrigation Efficiency) = 72.8 pounds of N/acre applied in the irrigation water.

Notes

Pounds of N/acre per inch	x Inches of ET of crop	x Irrigation Efficiency	= pounds of N/acre applied in the irrigation water

Simple Seasonal Nutrient Budget Planning:
Crop uptake – soil – water = need

Notes

	Crop Uptake	*- Soil	- Water	= Need
N (lbs/A)				
P (lbs/A)				
K (lbs/A)				

*If there are applications of compost, residue from a previous crop, or high OM%, include those items in the calculation

For example, if crop uptake is 100, soil is 10, and water is 5, need is 100-15 = 85 lbs/crop uptake – soil – water – other = necessity

- Use soil nitrate quick test (SNQT) to help guide timing of in-season fertilizer applications

Important
Calculating nutrients is complicated and should be used as a general guide. It is not possible to predict the precise needs of crops at the beginning of the season. Optimum management requires careful observation of crop growth and development, knowledge of plant variety, soil type and conditions, the climate and other factors that can change the growth and development of nutrients and their mobility during the entire season.

Soil Nitrate Quick Test (SNQT)

Soil Nitrate Quick Test (SNQT)

The SNQT can help guide in-season fertilization decisions. Mature/fruiting strawberries use an average of 1 to 1.2 pounds of nitrogen per acre each day. So within a 10-day period, an average of 10 - 12 pounds of nitrogen per acre is used by the crop. Equipment: a soil probe, a bucket, and a SNQT kit.

STEP 1

Determine Representative Soil Texture:

1. RCD or NRCS staff can print and help you interpret your soil map using the NRCS Web Soil Survey
2. Confirm the soil texture for your farm using the NRCS 'soil texture by feel' method. The texture may differ among different production blocks. You should not mix soils from areas with different textures when you are sampling

STEP 2

Collect Soil Samples from Representative Soil Texture:

1. Using soil map and experience, collect 15 soil samples from representative areas of the block
2. Collect soil using a 'zig-zag' or 'W' pattern so that soil from each representative area is collected
3. Probe to rooting depth (This will vary by crops. For strawberries a depth of approximately 12" is often used for mature plants, though 6" might be more appropriate for very young plants with immature root systems.)
4. Remove top 1-2" of soil in the soil sample probe
5. Mix soil by shaking bucket and stirring with your hand, or if a wet clayey soil, take pinches of soil from up and down the 15 soil strips

STEP 3

Perform Soil Nitrate Quick Test (SNQT)

1. Fill tube to 30 ml line with calcium chloride solution
2. Add soil until liquid level reaches 40 ml line. Cap and shake for 1-minute
3. Once solution clears, dip test trip for 2-3 seconds and shake once

- In coarse, textured soils,the solution becomes clear fairly quickly, in finer soils it may take half an hour or longer. The solution does not need to be completely clear, but you should be able to see your finger on the other side of the tube through the solution

4. After you have dipped the strip in the solution and shaken it off, wait one minute
5. Compare the color on the strip with the color chart. Write down the corresponding number for Nitrate (NO3). You should NOT wait longer than a minute to read the test result

© Fhoto by Terri Lajda, CRCD

Taking soil sample

Soil Nitrate Quick Test

STEP 4

Determine Nitrate-Nitrogen in Soil

1. Use the table to convert the NO_3 reading from the strip to parts per million (ppm) Nitrate-Nitrogen in the soil.

Approximate ppm Nitrate-Nitrogen using SNQT reading

Strip reading of Nitrate (NO_3)	Sand	Sandy Loam	Loam	Clay Loam	Clay
10	4	5	5	5	6
25	11	12	13	14	15
50	22	23	25	27	29
100	43	47	50	54	59
250	109	116	125	135	147

2. Determine ppm Nitrate-Nitrogen Available for the plant. This is based on the depth to which you took your sample:

Rooting Depth (Soil Depth Probed)	Multiply Reading by
6”	2
9”	3
12”	4

Soil Nitrate Quick Test

© Photo by Terri Lajda, CRCD

Example A **If your soil is Sandy Loam and your SNQT reading is 25**

Use the table to see that you have **12 ppm** Nitrate-Nitrogen in the soil
If the sample was taken to 12” depth, use the second table to multiply **12 ppm** times **4** . You have **48 pounds of Nitrogen per acre** currently available for crop uptake.

Example B **If your soil is Clay Loam and your SNQT reading is 100**

Use the table to see that you have **54 ppm** Nitrate Nitrogen in the soil
If the sample was taken to 9” depth, use the second table to multiply **54 ppm** times **3**. You have **162 pounds of Nitrogen per acre** currently available for crop uptake.

The general guideline “trigger point” for fertilization is < 50 ppm NO_3 (< ~11 ppm NO_3-N)
*A very general guide. Be conscious of the leaching of fertilizers with the irrigation water below the root zone such as “deep percolation”

STEP 5

Use this test result and consultation with UC Farm Advisors to help make the decision whether or not to fertilize. If the decision is not to fertilize, re-check nitrogen availability the next week by repeating this process.

IPM Terms

Integrated Pest Management (IMP) is a program to control pests and pathogens (insects, animal pests, diseases, and weeds) by combining the best methods for long-term control.

IPM is the process of:

1. **Monitoring:** Regularly monitor and keep good records
2. **Knowing the pest:** Know what the pest or pathogen looks like during different life stages. Know when and what action should be taken based on the life stage of the pest
3. **Using Preventive Cultural Practices, when effective:** Selecting resistant varieties, maintaining sanitary conditions are examples
4. **Using Mechanical Controls, when effective:** Hand weeding, vacuuming, and removing diseased plants are examples
5. **Using Biological Controls, when effective:** Release beneficial insects like predatory mites or use microorganisms
6. **Responsible Pesticide Use:** Use only when necessary and select not only for effectiveness but also to minimizing risks to human health and to the environment. Rotate chemical use to reduce pest and disease resistance

General definitions:

Pest: A living organism that is detrimental to the plant. A 'pest' can be a weed, microbe, bird, rodent, nematode or other organisms as well as insects.

Pesticide: A substance meant for impeding or killing plant pests.

Common types of pesticides related to plant protection products are called herbicides, insecticides, miticides, fungicides, nematicides, rodenticides, etc.

Regular monitoring

© Photo by Adriana Morales

Hedgerows for dust control and beneficial insect habitat

© Photo by Jack Kelly Clark, UC Statewide IPM Program

Conserve natural enemies

© Photo by Surendra K. Dara

IPM Fundamentals

Pest and Disease Management

- Regular and thorough monitoring to detect pests and determine infestation levels helps make appropriate treatment decisions.
- Promoting and maintain good plant health through nutrition and irrigation management helps the plants withstand pest damage. Deficiencies of certain nutrients or excessive application of others like nitrogen can increase pest problems.
- Good cultural practices can avoid or reduce pest burden. Managing lygus bugs on alternate hosts in winter before they migrate to strawberries; watering roadways or using low fences to prevent dusty conditions and spider mite build up; using drip irrigation, minimizing overhead irrigation and improving drainage to manage diseases like gray mold, angular leaf spot, and anthracnose; selection of pest and disease tolerant cultivars and well drained soils, and crop rotation are some examples of cultural practices for managing pests.
- Conserving and promoting natural enemies can also play a significant role in managing pests. Planting flowering host plants to provide habitat for natural enemies and using chemicals that are less toxic to natural enemies are some of the practices that promote biological control. Minute pirate bug(*Orius tristicolor*), big-eyed bug (*Geocoris spp.*), lacewings (*Hemerobius* spp. and *Chrysopa* spp.)], damsel bugs (*Nabis* spp.), lady beetle, parasitic wasps (*Encarsia pergandiella*, *Anaphes iole*, and *Peristenus* spp.), predatory mites (*Phytoseiulus persimilis*, *Neoseiulus californicus*, and *N. fallacis*) are among several predators that attack one or more strawberry pests. Releasing predatory mites for spider mite control is a common practice in California strawberry cultivation.
- Timely application of right chemicals is critical for managing pests and diseases. Rotating chemicals with different modes of action reduces the risk of pesticide resistance. If resistance is suspected, conducting a small test with intended chemical before field application is advisable.
- Proper diagnosis of pest or disease problems is important to make appropriate treatment decisions. Decisions based only on visual symptoms can be risky as some diseases cause similar symptoms.
- Combining and rotating botanical and microbial pesticides with chemical pesticides is a good IPM practice.
- Proper diagnosis of pest or disease problems is important to make appropriate treatment decisions. Decisions based only on visual symptoms can be risky as some diseases cause similar symptoms.
- Combining and rotating botanical and microbial pesticides with chemical pesticides is a good IPM practice.
- Obtaining clean transplants from a good source is important for avoiding many pest and disease problems in the production fields.
- Sanitize field by removing infected or dead plant material, ripe or infected fruit minimizes many diseases.

Consult the webpage: http://www.ipm.ucdavis.edu to obtain additional information regarding diseases, treatments with fungicides, and other management options.

Download free “IPMinfo” iPhone App for more information about strawberry pests and diseases.

© Photo by Julie Fallon, CRCD

Ladybug [lady beetle] is a predator that attack strawberry pests

© Photo by Misael Sanchez, CRCD

Release of predatory mites

Diseases

Name of Disease	Symptoms	Management
Angular Leaf Spot Caused by the bacteria *Xantomonas fragariae* 	Caused by the bacterium, ***Xanthomonas fragariae***, infection starts as tiny water-soaked lesions on the lower leaf surface which enlarge into translucent areas Between the veins exuding bacterial liquid. Upon drying exudate appears as a whitish film. As the disease advances, reddish brown spots – corresponding to the lesions on the lower side - appear on the upper leaf surface. These spots eventually become necrotic. Infected areas show yellowish margins. Bacterium can survive in the soil on infected plant material. Infected leaf surfaces serve as a source of inoculum that disperses with overhead irrigation or rain. Bacterium can cause vascular collapse and strawberry blossom blight.	→ Fumigation kills the inoculum in the soil → Using clean plant material and crop rotation minimizes the risk
Anthracnose Caused by the fungus *Colletotrichum acutatum*  	Lesions on petioles and runners are dark brown or black, lens-shaped, and sunken. Lesions appear as brown spots on green fruit and black spots on red fruit which are round to oval and sunken. Salmon-colored spores develop on lesions when conditions are warm and humid. Stunting, yellowing, and wilting of the plants, followed by death, can occur depending on the severity of the infection. Fungus can survive in the soil for several months without plant material. Certain weeds can also harbor the disease. Contaminated soil, field equipment, and infected weeds serve as a source of inoculum.	→ Fumigation or solarization in warm areas kills the soil inoculum → Washing soil from transplants, fungicide dips, hot water baths, using clean plant material, crop rotation, and good sanitation practices minimize the risk

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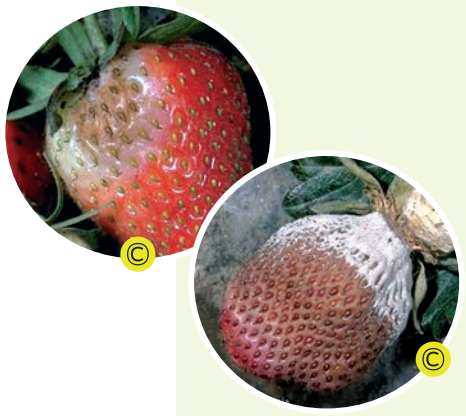
Diseases

Name of Disease	Symptoms	Management
Botrytis Fruit Rot Caused by the fungus *Botrytis cinerea* 	Small brown lesions are usually formed under the calyx on both green and red fruit. Lesions rapidly enlarge and are covered with velvety, gray-brown mats of fungal mycelium and spores. Infected areas rot and become soft which can turn dry and leathery if humidity is low. Spores are dispersed by wind or by water. Fungus can also infect flowers and either damages the tissue or remains dormant until fruit develops. Fungus remains in the soil on infected strawberry plant material or dead organic matter of other plants. Disease is prevalent in coastal areas because of wet and cool weather conditions.	→ Removal of infected, damaged, and dead flowers and fruits minimizes the inoculum → Growing strawberries in plastic tunnels minimizes the fungal infection → Good air movement and exposure to sunlight in the plant canopy reduces the risk → Apply fungicides to protect against and treat infection as needed
Charcoal Rot Caused by the fungus *Macrophomina phaseolina* 	Symptoms appear after the plant has been established and fruit production has begun or when the plants are subject to stress. The younger leaves in the center remain green, but the older leaves dry out and eventually die. Prior to the death of the plant, wilting of foliage is observed as well as a reduction in the growth of the plant. The vascular tissues and corticoles inside the crown become an orange to reddish brown color. The internal tissue of the primary roots can become dark brown. The foliage symptoms and discoloration of the tissues of the crown are similar to the wilting caused by Fusarium. The plants are predisposed to the disease when exposed to stress factors such as extreme climate conditions, drought, poor soil, or excessive weight from fruit. The fungus has a wide range of hosts and can survive in the soil as small black sclerotia.	→ The choosing of a place free of disease reduces the risk → Rotating crops with non-susceptible hosts can help to reduce the pressure from the disease → Cultivars such as Seascape and Chandler demonstrated some tolerance to carbonaceous mildew in greenhouse studies. → Good Care of the plants can help avoid stress factors that contribute to the development of the disease → Fumigating before planting can offer good protection, especially when the residues from the previous harvest have completely decomposed

© Photo by Heather Scheck, Agricultural Commission Office

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Diseases

Name of Disease	Symptoms	Management
Purple Leaf Spot A common disease in California, caused by the fungus *Mycosphaerella fragariae* (asexual form *Ramularia brunnea Syn. R. tulasnei.*)	Symptoms include small, deep purple lesions on the upper leaf surface. Center portions of the lesions turn brown then gray to white with age. Mature lesions have whitish centers and purple or reddish margins. Multiple lesions may coalesce and cause the death of the leaf. Other plant parts such as stolons, petioles, calyxes, fruit trusses, and fruits can also be infected. Fruit infection results in what is called the black seed disease. Tissue damage can weaken the plant and expose it to infection by other pathogens. Disease is commonly introduced through infected transplants. Small, black sclerotia on the infected plants germinate with sprinkler irrigation or rains and spores are dispersed by splashing water.	→ Fungicidal treatment in the nursery will control the disease → Use clean transplants free of disease to prevent introduction to the production field → Removal of the infected leaves minimizes the inoculum → Choose cultivars that are resistant to common leaf spot → Minimize sprinkler irrigation to avoid the dispersal of fungal spores → Apply fungicides when necessary
Skin Rot Caused by the fungus *Phytophthora cactorum*. Not common in annual strawberry plantations in California	The disease causes color changes from brown to purple on the surface of the plant. Infected fruit acquires a brown color and becomes soggy as the damage extends, creating a hard outer cape while the internal tissue remains smooth. The central cavity of the fruit may contain fungal mycelium. The fungus produces mobile spores called zoospores that can be spread by splashing from irrigation or from rain.	→ Good drainage in the field → Maintain a clean field by removing infected fruit → Fumigation and solarization kill the inoculum in the soil → Apply fungicides when necessary

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Diseases

Name of Disease	Symptoms	Management
Mucor Fruit Rot A fungal disease caused by *Mucor spp.*  ©	Fungus invades the fruit through ruptured skin and secretes an enzyme that causes leaky fruit rot. When humidity is high, infected fruit is covered by tough, wiry mycelium with black, round spore-bearing structures. Symptoms are similar to Rhizopus fruit rot. Fungus survives in dead and decaying organic matter.	→ Sanitize field by removing ripe fruit and plant debris and remove ripe and near-ripe fruit after rain to minimize incidence of disease → Handle fruit with care to avoid injury that can lead to the infection and rapidly cool fruit after harvest → Choose cultivars with thick cuticles which are less susceptible to the disease
Fusarium Wilt Caused by the fungus, *Fusarium oxysporum f. sp. fragariae*	Most of the disease symptoms and conditions that lead to the infection are similar to the charcoal rot caused by *Macrophomina phaseolina*. Younger leaves in the center remain green and alive, but the older leaves dry out and eventually die. Wilting of the foliage and stunted plant growth are also seen before plants die. Vascular and cortical tissues inside the crown turn orange to dark brown. However, internal tissues of the main roots are typically not discolored. Plants are predisposed to the disease when exposed to stress factors such as extreme weather, water shortage, poor soil or heavy fruit load. Unlike *M. phaseolina* which has a wide host range, *F. oxysporum f.* sp. fragariae is specific to strawberries. Fungus survives in the soil as small chlamydospores.	→ Choosing a location free of the disease reduces the risk → Crop rotation with other hosts may also reduce the disease pressure → Cultivars such as San Andreas and Ventana showed some tolerance to Fusarium wilt in greenhouse studies → Good plant care can avoid the stress factors that contribute to this disease → Fumigation before planting can provide good protection especially when crop residue has completely decomposed

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Diseases

Name of Disease	Symptoms	Management
Phytophthora Crown Rot A disease caused by *Phytophthora cactorum, P. citricola, P. parasítica* and *P. megasperma*, among which *P. cactorum* is the most common species.	Leaves are small and plant growth is stunted. Plants collapse as the season progresses. Crown vascular tissue or the entire crown tissue show brown discoloration when cut open. Infected roots develop black rot. Cool and moderate coastal California temperatures favor the disease. Pathogen survives in the soil and produces mobile zoospores which swim through saturated water and infect the plants. Pathogen can also produce chlamydospores and oospores which can survive in the soil without a host and withstand adverse conditions.	→ Choose a field that is well drained and free of the pathogen → Use transplants from a clean source → Soil solarization or fumigation will provide good control → Fungicidal treatments can also provide some protection
Mildew (Powdery Mildew) Common disease in California caused by the fungal pathogen, *Podosphaera aphanis*	Typical symptoms include white, powdery fungal growth on the lower surface of the leaves, upward curling of the leaf edges, and dry, purplish patches on the upper leaf surface as the disease advances. In addition to the leaves, flowers and fruit are also infected. Infected flowers fail to bear fruit or produce deformed fruit and die off. Infection hardens or desiccates developing fruit or gives a seedy appearance to mature fruit. Pathogen can survive over winter as mycelium or spore bearing structures called cleistothecia on transplants. Infected fields can also serve as a source of inoculum which are dispersed by wind. Dry leaf surfaces, cool to warm temperatures and high humidity favor the infection.	→ Clean nursery stock is important to prevent its introduction to the production fields → Avoid overhead irrigation during periods of infection → Optimal fertilization without excessive nitrogen application is also important → Choose cultivars that are resistant to mildew → Apply fungicides prior to the onset of symptoms for effective and sustainable suppression of the disease

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Diseases

Name of Disease	Symptoms	Management
Rhizopus Fruit Rot Fungal disease which is active most of the year in California caused by *Rhizopus spp.* 	Discolored, water soaked spots develop on the fruit and rapidly enlarge. Fruit wilts, turns brown, and becomes leaky due to the enzymatic activity of the fungus. White fungal growth with black, round spore-bearing structures called sporangia forms on the infected fruit under high humidity. Sporangia release thousands of spores when disturbed. Symptoms are very similar to Mucor fruit rot. Pathogen can survive very well as saprophyte on decaying organic matter and infects strawberries through wounds. The pathogen can survive over winter as mycelium or sporangiospores on organic debris.	→ Field sanitation is very important to manage Rhizopus fruit rot. Removing infected fruit and plants or fruit debris is critical in minimizing the spread of the disease → Handle the fruit with care and rapidly cool after harvest → Use cultivars with thick cuticles which can resist the infection → Apply fungicides if the disease is widespread throughout the field
Pallidosis Related Decline of Strawberry Viral disease caused by whitefly-transmitted viruses, Strawberry pallidosis associated virus (SPaV) or Beet pseudo yellow virus (BPYV) along with non-whitefly transmitted viruses 	Symptoms can be confused with those of nutritional deficiencies or abiotic disorders. Infection causes stunted plant growth, purple to red foliage, and brittle roots with reduced rootlets. Yield is severely affected in infected plants. Disease is transmitted by the greenhouse whitefly, *Trialeurodes vaporariorum* and aphids. Disease is not caused by SPaV or BPYV alone, but by the infection of SPaV or BPYV along with any of the several non-whitefly transmitted viruses. SPaV has a limited host range that includes strawberries, related species, and a few common weeds. BPYV has a wide host range that includes cucurbits and several weeds.	→ Use transplants free of infection → Control greenhouse whitefly and aphid vectors → Remove weeds that can act as virus reservoirs

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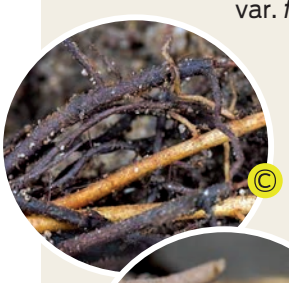
Diseases

Name of Disease	Symptoms	Management
Strawberry Leaf Blotch and Petiole Blight Minor fungal disease caused by *Gnomoniopsis comari* (synonym *Gnomonia comari*, anamorph *Zythia fragariae*) 	Tan to grey lesions on the first few leaves of the new plants rapidly expand from the margins and cover a quarter to half of the leaf's surface. Small, black to brown fruiting bodies on the lesions are characteristic of the disease. Fungus also causes petiole or calyx blight turning the infected areas brown to black. Disease is common in winter and early spring especially after heavy rainfall. Pathogen survives on strawberry residue in the soil and by splashing water.	→ Infected plants usually outgrow the disease and fungicide treatment is not recommended → Removal of strawberry crop residue reduces the risk
Verticillium Wilt Caused by the fungal pathogen, *Verticillium dahliae* 	Symptoms include stunted plant growth, marginal and interveinial browning on outer leaves followed by eventual collapse, and brownish black streaks or blotches on inner green leaves with stunted growth. Pathogen has a wide host range that includes several crop and weed species. Excessive nitrogen application can increase disease severity.	→ Use a clean field free of disease history → Crop rotation with broccoli or use of cereal rye or ryegrass as cover crops reduces the fungal inoculum in the soil → Soil solarization or fumigation is important for minimizing the risk of the disease → Avoid excessive application of nitrogen fertilizer
Red Stele Caused by the fungus *Phytophthora fragariae* var. *fragariae*  	Stunted plant growth followed by death in severe cases. As the leaves die on stunted plants, small younger leaves with short petioles are formed. Young lateral roots rot and new crown roots die backwards starting from the tips producing "rat tails". Infected roots have red discoloration on their core. Infections are normally limited to winter and early spring in California. Cool temperatures and saturated soils favor the disease. Fungus produces fungal zoospores which swim and infect the roots.	→ Well drained soils are important for reducing the risk of red stele → Use clean transplants → Avoid excessive irrigation → Soil solarization and fumigation can provide good control → Treat with fungicides as needed

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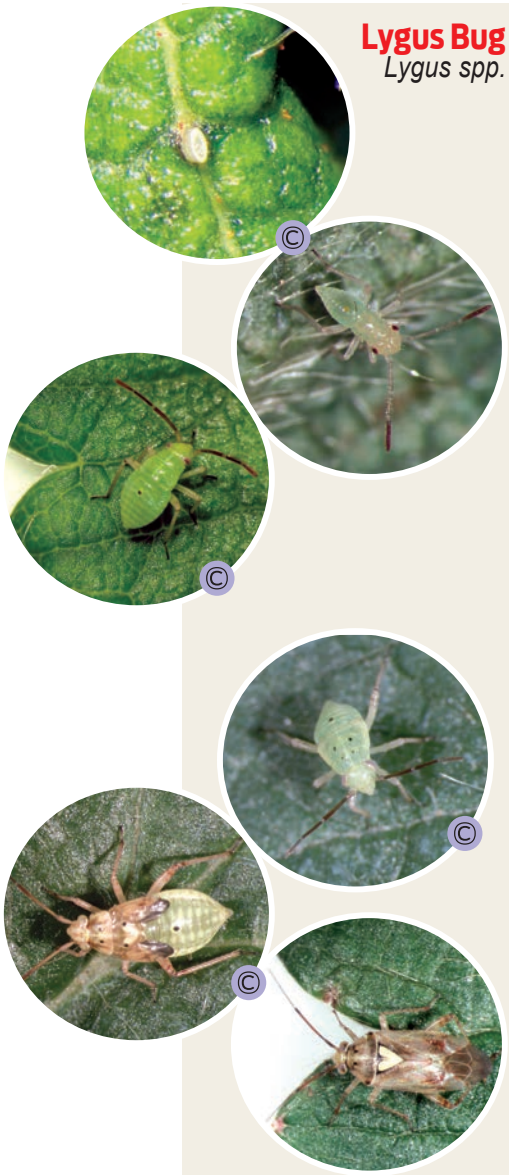
Pests

- Know toxicity levels for beneficial insects
- Understand the life cycle of pests so that pesticides can be more effective
- Chemical substances should be applied at the appropriate time and in the correct application method to manage diseases and pests
- Rotate pesticides through a "mode of action" which will help reduce the risk of pesticide resistance
- If you suspect a resistance to pesticides, conduct a small-scale test to analyze the effectiveness of the pesticide before applying it to the entire field
- Good sanitation practices such as removing infected plants, dead plants and/or fruit material will reduce many of these problems

Name of Pest	Symptoms	Management
Lygus Bug *Lygus spp.*	Multiple species of Lygus bug (*Lygus Hesperus*, *L. lineolaris*, *L. elisus*) exist in California causing significant losses to the yield and quality of strawberry fruit. **Biology:** Life cycle includes eggs, five nymphal instars and adults. Depending on temperature, it can take about 21 days from egg stage to adult emergence. Females start laying eggs in about 9 days and continue the process for 21 days. Eggs are mostly laid in the inflorescence. First instar nymphs are light colored. Second and third instars have a dark spot on the abdominal segment. Fourth and fifth instars have two spots on each of the first two thoracic segments. Developing wing pads are visible in the last two instars. **Damage:** Lygus bug punctures the plant tissue with its pointed mouth parts and feeds on the plant sap. Feeding causes damages to the achenes (seeds) resulting in fruit deformation as the fruits develop. Deformed or cat-faced fruits are not marketable.	→ **Cultural Control:** Lygus bugs thrive on flowering weed hosts like wild mustard and wild radish and migrate to strawberries when the weeds dry out. Managing weeds and managing hosts in winter before lygus bugs move to strawberries is important → **Biological Control:** Several species of natural enemies feed on various stages of lygus bugs. Big-eyed bugs (*Geocoris* spp.), damsel bugs (*Nabis* spp.), minute pirate bug (Orius tristicolor), parasitic wasp (Anaphes iole), and different spiders are among the common species of natural enemies. Providing refuge and using safer insecticides help conserve natural enemies → **Microbial Control:** Recent studies show promise for controlling lygus bugs with entomopathogenic fungus Beauveria bassiana → **Chemical Control:** Various groups of chemicals are registered for managing lygus bugs. Rotating different modes of action is ideal to reduce the risk of resistance development



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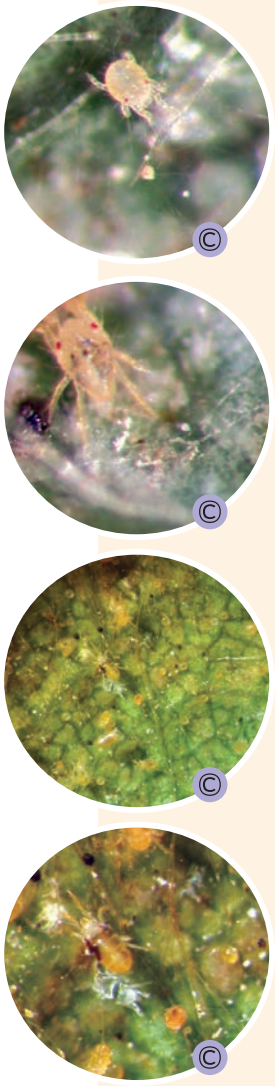
Pests

Name of Pest	Symptoms	Management
Spider Mites *Tetranychus urticae*	Different species of the twospotted spider mites occur on strawberries. The twospotted spider mite (*Tetranychus urticae*) is a common and major pest. The strawberry spider mite (*T. turkestani*) is also a frequently seen species. **Biology:** Life cycle includes egg, larva, protonymph, deutonymph, and adult stages. Eggs are round and clear. Larvae have three pairs of legs while nymphs and adults have four pairs of legs. Depending on temperature, spider mites can complete the life cycle in 1-2 weeks. Adult females are larger than males and are about 0.4 mm long. Females are oval and males are wedge shaped. **Damage:** Spider mites feed on the underside of the leaves, scrape the tissue, and suck the sap. They reduce the yield and quality of the fruits. Initial symptoms include stippling of yellow spots on foliage which advance to scarring and bronzing. Webbing can also be seen with infestation. In severe cases, leaves dry out and plants eventually die.	→ **Cultural Control:** Promoting vigorous plant growth through adequate chilling of transplants and good water and fertilizer management helps plants withstand mite infestations. Excessive nitrogen fertilizers can increase mite populations → **Biological Control:** Release of commercially available predatory mites such as *Phytoseiulus persimilis, Neoseiulus californicus,* and *N.fallacis* is common practice. Other natural enemies such as big-eyed bugs (*Geocoris* spp.), minute pirate bugs (*Orius tristicolor*), damsel bugs (*Nabis* spp.), black lady beetles (*Oligota oviformis*), brown lacewings (*Hemerobius* spp.), green lacewings (*Chrysopa* spp.), and sixspotted thrips (*Scolothrips sexmaculatus*) also play an important role → **Microbial Control:** Studies indicate effectiveness of entomopathogenic fungus, Beauveria bassiana against spider mites → **Chemical Control:** Various miticides are effective against spider mites. Choosing the ones that are less harmful to natural enemies enhances the effectiveness of biological control



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Pests

Name of Pest	Symptoms	Management
Cyclamen Mite *Phytonemus pallidus*	Cyclamen mites (*Phytonemus pallidus*) are not a common pest in fruit production fields. However, nursery infestation, if left untreated, can cause damage in production fields. These are very small mites and not visible to the naked eye. **Biology:** Life cycle includes egg, larva, pupa, and adult stages. Eggs are elliptical, opaque, and large compared to the size of adults. They are nearly half as long as adult females. Larvae are opaque and pupae are immobile. Adult mites are yellow or pinkish orange and shiny. Females are about 0.25 mm long and their fourth pair of legs appears as needle like structures. Males are less than 0.2 mm long and have modified hind legs which are used for transporting pupae or adult females. **Damage:** Cyclamen mites are usually seen at the midvein of unopened leaves and under the calyx of flower buds. Typical symptoms include crinkling of emerging strawberry leaves resulting in a compact leaf mass in the crown region. Severe damage results in stunted growth, withering of the flowers, and smaller fruits. If infestations are not controlled plants may fail to produce fruit.	→ **Cultural Control:** Obtaining transplants from a clean source prevents infestations in the production fields. This is the primary means of managing this pest. Hot water treatment of infested transplants is an option that has specific recommendations → **Biological Control:** Naturally occurring predatory mites are usually not effective. Commercially available *Neoseiulus californicus* may be effective. Some other natural enemies such as sixspotted thrips (*Scolothrips sexmaculatus*) and minute pirate bugs (*Orius tristicolor*) can feed cyclamen mites → **Chemical Control:** Certain miticides when carefully applied can be effective

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Pests

Name of Pest | **Symptoms** | **Management**

Western Flower Thrips
Frankliniella occidentalis

Western Flower Thrips, *Frankliniella occidentalis* (WFT), are a common pest of strawberry production in California. Sometimes, small amounts of onion thrips can be seen alongside WFT.

Biology: Life cycle includes egg, two larval instars, prepupa, pupa, and adult stages. Eggs are white, oval to kidney shaped, and 0.2 mm long. They are laid inside leaves, flower buds, and petals and are usually protected from insecticidal applications. Eggs hatch in 2 to 4 days into larvae which are yellowish, wingless, and have reddish eyes. Larvae feed on flower buds and terminal foliage.

As they mature, larvae stop feeding, drop off to the soil, and become prepupae. Prepupal stages last for about two days before pupae are formed. Since they live in the soil, pupae are less exposed to insecticidal sprays.

Adults are slender insects that are less than 2 mm long. The have hairy wings that are folded alongside the length of the body at rest. The body color of adult thrips can be yellow, orange, brown or black resulting in light, dark, or intermediate morphs. Duration of the life cycle depends on the temperature and can vary from 2-6 weeks. Adults can live for several weeks in California's climate.

Damage: Thrips feed by piercing and rasping the plant cells and sucking the contents, which results in cell collapse. They feed on foliage, inflorescence, and fruits. Damage to strawberry fruit is called bronzing (Type 1 bronzing) due to its brown discoloration.

→ **Cultural Control:** Avoid or monitor proximity to other crop or weed hosts

→ **Biological Control:** Minute pirate bugs (*Orius* spp.) and predatory mites (*Neoseiulus* spp.) feed on thrips. Some of these are commercially available

→ **Microbial Control:** Entomopathogenic nematodes and entomopathogenic fungi such as *Beauveria bassiana* can be effective with proper timing and application. Recent studies indicate fair to good success of *B. bassiana* against WFT

→ **Chemical Control:** Various chemical insecticides are available for managing WFT. Using chemicals that do not harm natural enemies will enhance the pest control's efficacy

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Pests

Name of Pest | **Symptoms** | **Management**

Greenhouse Whitefly

Trialeurodes vaporariorum

Greenhouse whitefly (*Trialeurodes vaporariorum*) is a common pest in strawberries, but usually does not require targeted treatments. Populations can, however, develop to large numbers which requires attention.

Biology: Life cycle includes egg, nymph, and adult stages. Small (about .25 mm) spindle-shaped eggs are laid on the underside of leaves in a circular or semicircular manner attached to the underside of the leaves with a petiole or stalk. They are yellowish when new and become dark as they mature in 6-7 days. There are four nymphal or larval instars. The first instars, known as crawlers, are light green. Crawlers move around in search of ideal feeding sites, insert their mouthpart into leaf tissue and settle down. The next two instars are immobile and have nearly transparent and flattened bodies. Depending on temperature larval stages last from 9-17 days where first, second, and third instar duration is 3-5, 4-8, and 2-4 days respectively.

The final instar referred to as a pupa is not a true pupa. It is characterized by long, waxy filaments along the outer edge. Pupae mature in 3-7 days.

Adults are about 1 mm long, pale yellow, with two pairs of white wings covered with powdery wax. When at rest, wings are held parallel to the top of their body.

Damage: Whiteflies feed on plant juices and reduce plant vigor and yields when in large numbers. Adults secrete honeydew which promotes the growth of sooty mold which further reduces the quality of the plant.

→ **Cultural Control:** Isolation from susceptible hosts and proper handling of the crop residue are important in avoiding whiteflies

→ **Biological Control:** Various natural enemies generally keep low populations of whiteflies under control. Important natural enemies include big-eyed bugs (*Geocoris* spp.), minute pirate bugs *Orius* spp.), lacewings (*Chrysopa* spp. and *Chrysoperla* spp.), and parasitic wasps like *Esncarsia pergandiella*

→ **Microbial Control:** These are several entomopathogenic fungi that are pathogenic to whiteflies. Recent field studies have shown that *Beauveria bassiana* showed some promise

→ **Chemical Control:** Various groups of insecticides are effective against whiteflies

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Fruit Management

To guarantee that the highest quality fruit is harvested, take into account the purpose or destination of the fruit (fresh or cooler), weather conditions of the harvest, food safety, and measures of fruit quality.

Preparing for the Harvest

Recordkeeping

- Buyers, from cooler companies especially, can ask you for a record of pesticides before making a purchase. Make sure you select the appropriate chemical substances and properly schedule the application of such pesticides so that fruit may be picked within the Post-Harvest Interval (PHI) indicated on the tag.

Harvesting Interval

- It is necessary to harvest the fruit every 2-3 days depending on the temperature and market demand. Consider Restricted Entry Intervals (REI) of pesticides when scheduling the harvest.

Climate

- Fruit should be harvested early in the morning during cool conditions. This reduces the amount of fruit that can be harmed by midday and afternoon heat after being harvested. For example, buyers from fresh markets may ask you to postpone harvesting if temperatures reach 80ºF.
- During periods of heavy rain, damaged fruit should be harvested from the plant and removed continuously.

Important

Keep the fruit out of the sun at all times. Freshly picked fruit perishes quickly, especially in hot conditions.

Harvest for frozen market

Harvest for fresh markets

Dispose of bad fruit

Transferring of fruit to cooler

© Photos by Terri Lajda, CRCD

Fruit Management

Workers

- It may be challenging to have sufficient workers to harvest all of the fruit for the entire season for all the different markets; to have the fruit ready to be harvested daily to attract a consistent labor force. Workers who harvest for the cooler market must know how to effectively operate special tools (stainless steel cutters and picking ring) used to cut the calyx of the fruit

Hygiene

- Workers (pickers) who harvest the fruit must have good hygiene. This includes clean and short fingernails. Workers must wash their hands with soap and water after using the restroom. Anyone who handles the fruit must wear gloves to avoid contaminating the fruit when being harvested and processed for the "cooler market"
- Consult the Food Safety section and communicate with the CSC for a complete list of hygiene procedures

Control of Fruit Quality

- Harvested fruit should be healthy and clean
- It is recommended that each group of pickers utilizes a "field table" to inspect the quality and packaging of the fruit. Fruit is subject to quality control. The fruit inspector receives and verifies that the fruit is in good condition. At the same time, the picker receives credit for payment for picking a flat
- Harvested fruit should be kept in the shade and be taken to a cold warehouse at a refrigerated facility. Fruit loses approximately one day of shelf life for every hour that a harvested fruit is not refrigerated
- Create a detailed harvesting plan for the transferring of the fruit to a cold facility. Coordinate with the cooler for receipt of a shipment

Harvest for fresh market

Harvest for frozen market

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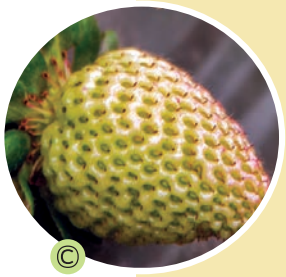
Fruit Quality

Stages of Maturation of Fruit

© Photos by Terri Lajda, CRCD
© Photos by Misael Sánchez, CRCD

Point of Maturity	Recommendations
 **Green or White**	▪ Fruit often rips when separated from the plant ▪ Fruit has a sour and unpleasant taste ▪ Fruit is never red ▪ Fruit should not be harvested
 **Some red; Somewhat green or white**	▪ Minimum age of maturity that fruit may be sold for export ▪ Possibly has a white tip
 **Mainly red; A bit of white on top part**	▪ Optimum maturity for fresh and cooler markets ▪ Fruit can be easily separated from plant ▪ Fruit is firm ▪ Fruit has a pleasant taste and can maintain its quality for days
 **Completely Red**	▪ Maximum maturity that can be sold at a fresh market ▪ Bright Red and very sweet ▪ Can be optimum for direct market if transferred quickly ▪ Fruit may weigh more causing it to pay out better in the freezer market
 **Dark Red**	▪ Maximum maturity that can be sold in freezer market ▪ Fruit has matured into an “extremely mature” stage that for the most part causes the fruit to be soft ▪ The only market for fruit of this level of maturity is jams, juices, and ice cream, etc. ▪ Fruit at this stage should be discarded if it is too dark, soft, deformed or if it has any rotting or soft spots

Santa Maria Valley and Southern San Luis Obispo County

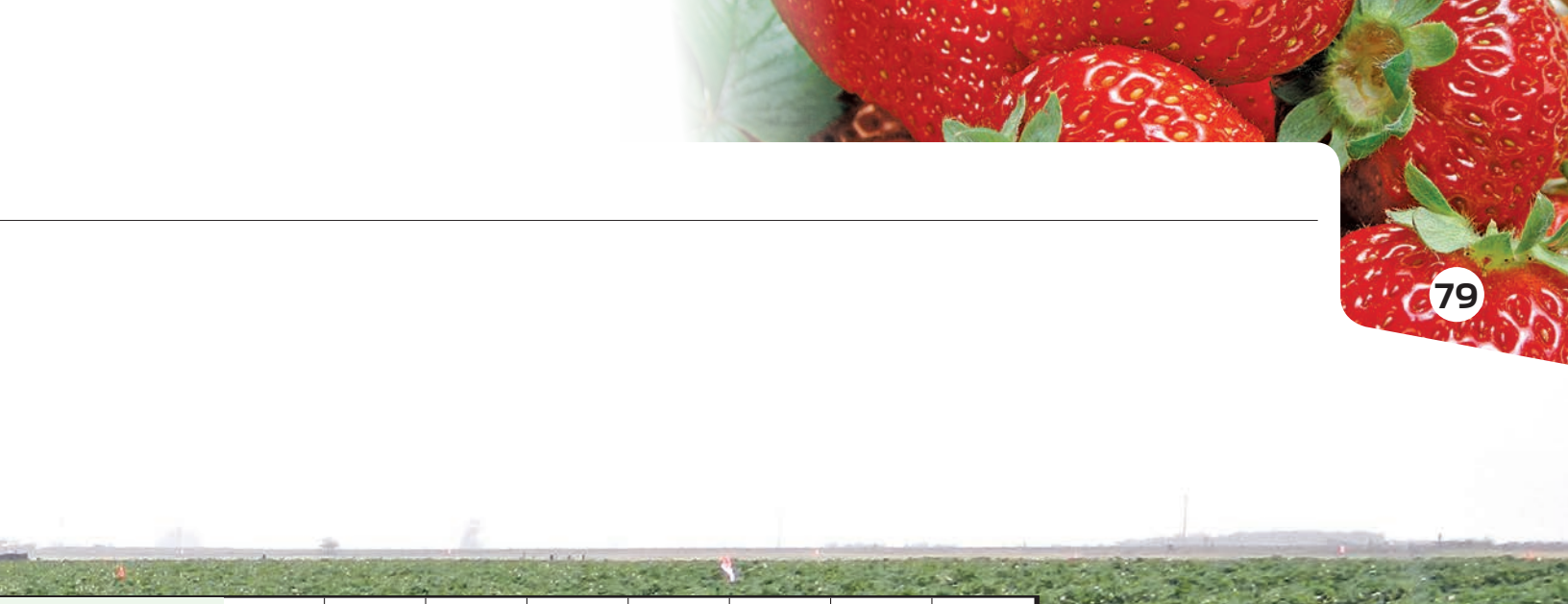
Production Calendar

The production in Oxnard/Ventura begins first while production in Salinas/Watsonville begins last. This calendar should only be used as a general guide for some of the conditions of production for other cultivating regions. Consult your local UCCE Farm Advisor for more information.

Common Practices for Strawberries	JUN	JUL	AUG	SEP	OCT
Send soil sample to the laboratory					
Land preparation for planting					
Sprinkler Irrigation					
Fumigation					
Variety Selection					
Summer/Winter Planting					
Summer Harvesting					
Spring Harvesting					
Winter Harvesting					
Second Year Strawberries					
Periods of Rain					
Weeds					

	JAN	FEB	MAR	APR	MAY
Disease Management					
▪ Angular Leaf Spot					
▪ Anthracnose					
▪ Botrytis Fruit Rot					
▪ Purple Leaf Spot					
▪ Mucor Fruit Rot					
▪ Fusarium Wilt					
▪ Phytophthora Crown Rot/Vascular Collapse					
▪ Mildew					
▪ Rhizopus Fruit Rot					
▪ Strawberry Leaf Blotch and Petiole Blight					
▪ Verticillium Wilt					
▪ Red Stele					

	JAN	FEB	MAR	APR	MAY
Pest Management					
▪ Lygus Bug					
▪ Spider Mites					
▪ Western Flower Thrips					
▪ Greenhouse Whitefly					

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Service Providers

Some regulatory agencies do not provide free technical service. A list of technical assistance providers (TSP's) can be found below and the agencies cooperate between each other. When you speak with bilingual personnel, make sure to ask for the telephone numbers of other bilingual technicians. You can write down the names and telephone numbers here as a reference. Bilingual technicians can help you obtain information that you may need. Please ask for assistance!

Farm Advisors from the University of California Cooperative Extension (UCCE) conduct and extend strawberry research. Local Farm Advisors are experts of the growth of strawberries, nutrient management, irrigation management, Integrated Pest Management, and small scale agricultural operations. Many Farm Advisors are bilingual.

Natural Resource Conservation Services (NRCS) in association with **Resource Conservation Districts (RCD's)** provide technical assistance to promote healthy soil and conserve natural resources. Cost-share programs from the NRCS are available.

Farm Services Agency (FSA) provides loans and insurance for eligible growers. The person to contact on the Central Coast is Gary Troester, telephone 805-928-9269 x118.

Central Coast Coalition of Ag Water Quality (The Coalition) works directly with producers and ranchers to protect the water quality on the Central Coast from San Mateo to Santa Barbara. The person to contact is Erin McCarthy, telephone 831-475-5159.

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San Mateo County:
RCD 650-712-7765
NRCS 650-726-4660
UCCE 650-726-9059

San Benito County:
RCD 831-637-4360 x101
NRCS Servicio 831-637-4360 x3
UCCE 831-637-5346

Santa Clara County:
RCD 408-847-4171
NRCS 831-637-4360 x3
UCCE 408-282-3110

Santa Cruz County:
RCD 831-464-2950
NRCS 831-475-1967
UCCE 831-763-8040

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Monterey County:
RCD 831-424-1036 x124
NRCS 831-424-1036 x101
UCCE 831-759-7350

San Luis Obispo County:
RCD Norte 805-434-0396 x4
RCD Costa/Sur 805-771-9835
NRCS 805-434-0396 x3
UCCE 805-781-5940

Santa Barbara County:
RCD 805-928-9269
NRCS 805-928-9269
UCCE 805-781-5940

Ventura County:
RCD 805-764-5130
NRCS 805-386-4489
UCCE 805-645-1451