ORGANIC PEPPER PRODUCTION ON CALIFORNIA'S CENTRAL COAST:
A Guide for Beginning Specialty Crop Growers

Introduction

Peppers are an excellent addition to most small-scale, organic mixed cropping systems that focus on local sales. Peppers are highly productive, and will reliably produce fruit from July through October without season extension technologies (such as hoop houses). They are relatively easy to grow and harvest, and provide multiple marketing and culinary options. Peppers can be harvested green or left on the plant to develop color. They offer many possibilities for adding value through processing or drying. Flavor options range from sweet to very hot. A variety of colors, shapes, and sizes allows for striking presentations at farmers' markets and in Community Supported Agriculture (CSA) boxes.

This grower guide addresses the basic production steps in growing peppers organically in California's Central Coast region and provides a varieties' overview for those interested in adding peppers to their specialty crops.

Features of pepper production

- Peppers grow well in most Central Coast locations
- Relatively pest- and disease-free
- Easy and fast to harvest
- Do not bruise or crack easily
- Provide continuous harvest over a long period
- Highly sought after by chefs, retailers, wholesalers, and home cooks
- Highly adaptable from fresh market to processing
- Season can be extended using high tunnels

PRODUCTION PRACTICES — SUMMARY

Climate
- Warm season crop.
- Perform best when daytime temperatures don't exceed 90° F; higher temperatures limit pollination and increase potential for sunburn of fruit.

Soil type
- Grow well on soil types from sandy loams to heavier clay soils.
- Perform best on heavier soils with CEC (cation exchange capacity) ratings greater than 12.
- May require supplemental fertility throughout the growing season on lighter-textured soils.
- Require good drainage to minimize soil borne fungal diseases.

Fertility requirements
- Peppers require relatively high fertility.
- Incorporate legume/cereal cover crop and 5–7 tons/acre of compost before planting.
- Peppers may require supplemental fertility to maintain growth and good fruit production (see page 6).

In the greenhouse
- Buy fresh seed every year.
- Start plants in greenhouse early to mid February, 8–10 weeks before transplanting.
- Use heat mats under seed flats to promote seed germination.

Soil temperature
- Transplant when the threat of frost is past, and soil temperatures are greater than 60° F at planting depth (6") for 5–7 days.
- The best window for transplanting on the Central Coast is mid April through May.

Plants per acre
- 12,000–14,000, varies depending on spacing and growth habit.

Planting technique
- Transplant starts by hand, or with a mechanical transplanter for blocks larger than 0.25 acres.

Bed spacing
- Plant peppers in a single line on beds spaced 36" center to center; single line planting facilitates cultivation.
- Plant in double lines on beds spaced 40–60" center to center (standard spacing in most production systems). Double lines may help shade fruit and protect against "sunburn."

Plant spacing
- 1–2' between plants, depending on row spacing and growth habit of the variety.
- Total plant populations of 12,000–14,000 plants per acre, vary depending on spacing and growth habit.

Planting depth
- Place transplants as deep as possible into pre-irrigated beds that have adequately dried down while keeping all foliage above ground.

Irrigation
- Drip tape facilitates uniform water application, saves on water costs, and minimizes both weed and disease pressure.
- Avoid excessive soil moisture to prevent *Phytopthera* spp. (root rot).

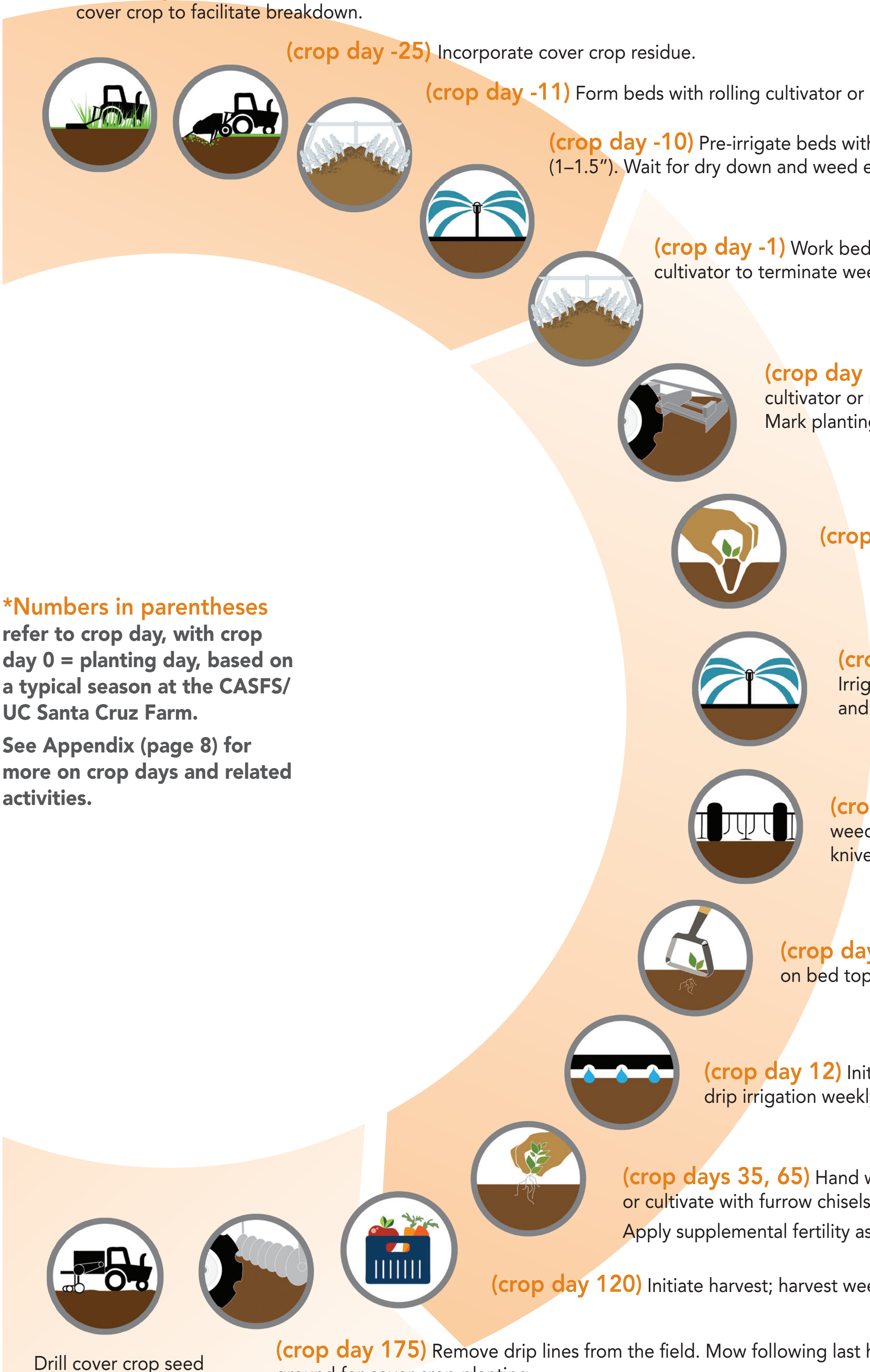
Days to maturity
- Depends on varieties and weather conditions—most peppers are ready to harvest approximately 90 days after transplanting.

Harvest tips
- For small-scale production (blocks < 1 acre), harvest into 5-gallon buckets; walk buckets to the edge of the field for sorting/packing.
- Cull in the field: pick and discard fruit that is sunburned, insect damaged, or has had soil contact that will cause rotting.

Post-harvest handling
- Easy post-harvest handling: light to carry, do not bruise easily, and do not require washing.
- Store well in cooler for 7–10 days.

Crop rotation
- Rotate peppers from other solanums and strawberries every four years, if possible, to minimize buildup of soil-borne fungal disease pathogens.

PRODUCTION SEQUENCE — SUMMARY



(crop day -25*) In spring, mow cover crop to facilitate breakdown.

(crop day -25) Incorporate cover crop residue.

(crop day -11) Form beds with rolling cultivator or listing shovels.

(crop day -10) Pre-irrigate beds with overhead irrigation (1–1.5”). Wait for dry down and weed emergence.

(crop day -1) Work bed surface lightly with cultivator to terminate weeds.

(crop day -1) Shape beds using rolling cultivator or rototiller/shaper combination. Mark planting rows.

(crop day 0) Plant transplants.

(crop days 0, 1, 4, 7) Irrigate (overhead) to water in and establish transplants.

(crop day 11) Cultivate for weed management (sweeps, knives).

(crop day 11) Hoe out small weeds on bed tops. Lay drip lines.

(crop day 12) Initiate drip irrigation; run drip irrigation weekly.

(crop days 35, 65) Hand weed large weeds as needed or cultivate with furrow chisels and sweeps.

Apply supplemental fertility as needed through drip lines.

(crop day 120) Initiate harvest; harvest weekly July through October.

(crop day 175) Remove drip lines from the field. Mow following last harvest. Prepare ground for cover crop planting.

Drill cover crop seed prior to fall/winter rains.

***Numbers in parentheses refer to crop day, with crop day 0 = planting day, based on a typical season at the CASFS/ UC Santa Cruz Farm.**

See Appendix (page 8) for more on crop days and related activities.

Production Practices — Additional Details

Initial fertility

Because pepper plants have a long season—they may be in the ground for up to 8 months with a production window up to 4 months, or longer if season extension is used—they have a relatively high fertility requirement compared to many other crops.

Adequate early season fertility is critical to help plants develop a strong scaffold to hold fruit, and adequate foliar coverage (enough leaves) to protect fruit from sunburn. On heavier soils (CEC ratings greater than 12), fertility requirements of peppers through the season may be met by incorporation of a legume/cereal cover crop, and 5–7 tons per acre of high quality compost prior to planting.

Timing

Plant as early in the spring as is reasonable based on the estimated date of last frost and soil temperatures. Peppers continue to produce fruit as long as temperatures allow for pollination (< 90° F), and fertility and moisture are adequate. Harvest weekly from first fruit (July) through late fall. Because a single planting has a long harvest season, there is no need to stagger plantings.

HIGH TUNNELS FOR SEASON EXTENSION

Commercial pepper producers in the Hollister area (San Benito County) have increased yields and extended harvest of peppers using high tunnels. The temperatures in the tunnels significantly extend the season and allow peppers to develop their full color (red, yellow, "chocolate," etc.). These fully mature peppers typically sell for a premium in the specialty and wholesale markets.

Planting

In a hand-transplanted, single-line system, form a trench approximately 4" deep down the middle of each bed using a small shovel or bed shaper, and transplant into the trench). This shallow trench will improve soil water retention at time of planting, will allow for easy placement of the drip line, and will greatly facilitate weed suppression.

Plant transplants that are tall, with a well-established root system, and well hardened off (Figure 1). Soak the nursery trays prior to planting to ensure good moisture at time of transplant. Plant as deep as possible (keeping foliage above ground) to ensure good root contact with moist soil and encourage adventitious rooting (roots that sprout from the buried stem); Figure 2.

FIGURE 1. Use tall transplants with well-developed root systems. *Photo: Elizabeth Birnbaum*

FIGURE 2. Deep planting ensures good root contact with moist soil and encourages adventitious rooting. *Photo: Elizabeth Birnbaum*

Irrigation

Irrigate (overhead or drip) as soon as possible after transplanting to ensure good initial growth and minimize transplant stress. Keep plants moist until deeper roots are established (~10 days; Figure 3). Assuming there is deep soil moisture from winter rains or pre-irrigation, initial irrigations can be light (2–3" in first 2 weeks). If using overhead for initial irrigations, switch to drip lines after 2 weeks.

Once the plants have extended roots below the root ball, decrease irrigation frequency until the canopy is established. As the weather warms up, irrigate weekly on heavier soils, and 2–3 times a week on lighter soils.

Calculate irrigation amounts based on estimated evapotranspiration (Et) losses using local CIMIS station data (cimis.water.ca.gov) or other source. During the initial growth stages, multiply estimated Et losses by percent canopy. For

FIGURE 3. Initial overhead irrigation on pepper transplants helps establish plants. *Photo: Elizabeth Birnbaum*

example, when the canopy is at 25%, replace 25% of the daily estimated Et loss. Increase proportionally until the plant is in full canopy and irrigation amounts equal the estimated Et loss as reported by CIMIS. Avoid overwatering to minimize both weed pressure and nutrient leaching.

Weed control

Good weed management in peppers begins with careful field selection. Avoid weed pressure from grasses and perennial weeds, since these are both difficult and expensive to manage once the peppers are established. This is critical to organic pepper production, because the peppers will be in the ground for up to 8 months.

Use pre-irrigation whenever practical; it can save significant weeding costs and ensure deep moisture to facilitate good initial crop growth and establishment. Form beds, then overhead water with 1–1.5" of water. Following weed flush, rework beds with a rolling cultivator or other suitable cultivation tool to destroy newly germinated weeds prior to planting. See the publication *Tillage, Bed Formation, and Planting to Moisture* in this **Grower Guide** series for additional details.

Once plants are established, move the soil toward the plant using a rolling cultivator. This "dirting" pass will fill in the planting trench, smother newly emerged weeds within the plant line, brace the plants, and cover the drip line. However in milder climates where peppers do not grow tall before fruiting, dirting or hilling must be done minimally, if at all, in order to prevent fruit set on the hilled soil that can lead to rot.

During the early stages of crop growth weeds can be easily managed between planted lines using standard row crop cultivation equipment including sweeps, side knives, and small chisels in the furrows to break wheel compaction.

When planting double lines per bed, you may need to hand weed between plants, since it is much more difficult to manipulate soil to bury weeds within the plant line.

Assuming there are no problem perennial weeds in the field, and irrigations are well-timed and not over-applied, the field should remain relatively weed free for the duration of the crop cycle. Hand pull any escaped weeds during harvest and irrigation operations.

Peppers at the Everett Family Farm's farmstand, Soquel, California.

VARIETAL OVERVIEW

Select "trendy" varieties for direct sales. Consumers are especially attracted to large and "mini" fruit. Spicy peppers high on the Scoville scale (spicy heat index; see en.wikipedia.org/wiki/Scoville_scale) are not big sellers at farmers' markets. Plant hot peppers in small quantities, if at all, unless you have a known sales outlet.

Popular, attractive pepper types:

LARGER BELLS

Lamuyo (elongated bells) source: Reimer Seeds

Reina	Mama Mia Giallo
Gemini	Lido Lamuyo

Bullhorn varieties

FULL SIZE	MINIS
Corno Di Toro	Cornito Rosso (red)
Carmen (red)	Cornito Giallo (yellow)
Escomillo (yellow)	

Blocky Bells

Flamingo (orange/red)	Admiral (yellow)
Gourmet (yellow/early)	Quadrato D'Asti Giallo/Rosso
Double up (red)	Aristotle (red)

New Mexico pod types (red or green) a.k.a. Anaheim, Hatch, etc.

Anaheim (late)	Highlander (big, high yield)
Joe E. Parker (heirloom)	

Minis: pimientos, lunch box, snack types: Johnny's seeds lunch box varieties

Eros	Cupid

Ethnic frying types

Jimmy Nardello	Shishito
Cubanelle/Biscayne	Banana types (sweet and hot)
Padron	

Note that both padron and shishito peppers are good "niche" peppers that have become important income generators on small farms.

Other small-fruited varieties

Pimiento types (Round of Hungary)

Aura, Lipstick, Glow (4–5" top shape, early, sweet)

These varieties are as sweet or sweeter than bell peppers, easier to grow, and much earlier.

Anchos/Poblanos

Tiburon (biggest, best variety)

Jalapenos

El Jefe and Jalafuego (biggest, best taste)

Supplemental fertility

Apply supplemental fertility to peppers grown on lighter-textured soils with low CEC (<12) to maintain good leaf growth (essential for minimizing sunburn) and adequate production through the last few months of the production cycle. Check soil nitrate levels following initial crown set to assess the need for additional fertility; N>20–25 ppm is required to support ongoing fruit set.

Although expensive (approximately $7/lb of N), organic liquid formulations (4-2-0 or 4-0-0) applied directly through the drip lines via injection into the irrigation header may be the most viable option for post-plant amendment application.

Alternately, you can "band" dry, granulated or pelleted formulations of N-based animal waste products into the soil close to the plants for root uptake. However, it is more effective to incorporate fertilizer ahead of planting.

Staking

Some growers support pepper plantings by placing stakes along the outside of the rows and running a single string line from stake to stake. This helps keep the plants upright and minimizes broken branches from both wind and heavy fruit set. The stakes are typically only as high as the pepper plant (+/- 2').

FIGURE 4. Gently move foliage aside to find ripe peppers for harvest. *Photo: Jim Clark.*

Harvest

Harvest is systematic—it requires tracking where harvest has occurred to maximize efficiency and minimize loss. Inspect each plant for mature fruit by gently moving branches and leaves to reveal hidden peppers (Figure 4). Remove peppers by hand and place them in a 5-gallon bucket while moving down the row.

To harvest a pepper, pull fruit gently from the stem end of the pepper, taking care not to break either the stem or the branch holding the fruit. Many varieties can be harvested with a single hand by placing the thumb near the zone of abscission (the point where the stem attaches to the branch) while gently pulling at an angle to separate the fruit from the branch (Figure 5). This takes practice! Some varieties require two hands and significant care to harvest successfully.

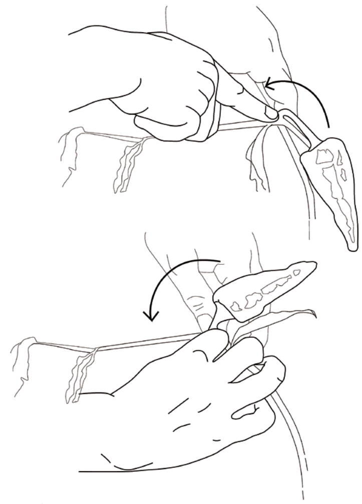


FIGURE 5

During the harvest, remove any unmarketable fruit (e.g., misshapen, insect-damaged, sunburned, rotten) from the plant and leave it in the field. This maximizes future harvest efficiency. Early fruit often sets between branches where it will become deformed as it grows; such fruit should be removed and discarded. Most fruit that contacts the soil will develop a rot spot at the point of contact; this too, must be discarded.

Harvesting small-fruited varieties (e.g., padrons) requires significant labor, not only because of their size, but because they are harvested at a relatively immature stage for optimum market quality, and thus must be harvested more frequently than larger varieties. Leaves easily camouflage the dark green 'Padron' variety, requiring significant "searching" to harvest them properly.

Other varieties can be harvested when fully sized and still green; most can also be left on the plant to mature and color up. Colored peppers (orange, red, yellow, brown) sell for a premium price. However, because of the additional time needed to reach full maturity, there is significant risk in getting a marketable fruit at the fully mature and colored stage, since this growth stage is much more prone to sunburn and insect feeding.

Post-harvest handling, storage

Weigh and pack harvested peppers into crates or boxes (no washing necessary, Figure 6). Peppers will store well in the cooler for 7–10 days if not marketed immediately.

FIGURE 6. Bell peppers harvested for UCSC Dining, UCSC Farm.
Photo: Martha Brown

Post-harvest field care

Following the final harvest, pull the drip lines, mow the plants, and disc the field in preparation for a subsequent crop or cover crop. Pepper plants are easily chopped up by the mower, producing minimal biomass and a clean seed bed for cover crops. A single pass with a disc is more than adequate.

Crop rotation

Rotate peppers from other solanums and strawberries every four years, if possible, to minimize buildup of soil-borne fungal disease pathogens. Plant peppers into production blocks that are free of perennial weeds and grasses, are relatively high in fertility, and have good soil tilth and drainage—in other words, plant peppers in your best ground, whenever possible.

Pests and Diseases

Before you select varieties and plant your pepper crop, look up common pests and diseases that affect the crop in your area. Learn about pest and disease life cycles, prevention practices, and possible treatments using resources such as the UC IPM website (ucipm.edu), your county Cooperative Extension offices, ATTRA's Biorationals: Ecological Pest Management Database (www.ncat.org/attra-pub/biorationals), neighboring farmers, and other knowledgeable professionals.

The main pepper arthropod pests in the Central Coast region are:

- Thrips. Western flower thrips, *Frankliniella occidentalis*. Onion thrips, *Thrips tabaci*. Chili thrips, *Scirtothrips dorsalis* and other species: can be vectors of Tomato Spotted Wilt Virus (TSWV; see below).
- Aphids: Green peach aphid, *Myzus persicae*: feed on plant juices and can transmit viruses; exude honeydew that can coat fruit and be difficult to remove.
- Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata*. Western striped cucumber beetle, *Acalymma trivittatum*: feed on foliage and fruit calyxes.

The main pepper diseases in the Central Coast region are:

- Powdery mildew caused by *Leveillula taurica* (*Oidiopsis taurica*): infected leaves curl up and leave fruit vulnerable to sunburn.
- Tomato spotted wilt virus (TSWV) in the tospovirus group: symptoms vary with the stage of growth infected, the cultivar, other viruses, and environmental conditions, but typically include spotting, bronzing, dying leaves, and ringspots on fruit. Affected fruit is not marketable.

Please see *Organic Pest and Disease Management in Selected Crops on California's Central Coast* in this **Grower Guide** series for information on the pests and diseases listed here, and suggestions for their control.

ADDITIONAL RESOURCES

ATTRA question of the week: What do I need to know about organic sweet pepper production and where can I get the information?
attra.ncat.org/calendar/question.php/what_do_i_need_to_know_about_organic_swe

Introduction to weed management in a small-scale organic production system (video). Produced by the Center for Agroecology & Sustainable Food Systems. www.youtube.com/user/casfsvideo

Knock weeds out at critical times, by Mark Schonbeck. eOrganic, 2010. articles.extension.org/pages/18882/knock-weeds-out-at-critical-times

Resource guide to organic and sustainable vegetable production, by Steve Diver et al. ATTRA 2001; updated 2012. NCAT IP188. attra.ncat.org/attra-pub/summaries/summary.php?pub=19

UC IPM pest management guidelines: Peppers. University of California, DANR Publication 3339. ipm.ucanr.edu/PMG/selectnewpest.peppers.html

Organic Pepper Production on California's Central Coast: A Guide for Beginning Specialty Crop Growers by Jim Leap, Orin Martin, Darryl Wong, and Kirstin Yogg-Comerchero, with contributions from Ann Baier and Doug O'Brien. Edited by Martha Brown and Ann Baier.

 This information was developed for beginning specialty crop growers and is based on practices used at the UCSC Farm. CASFS is a research, education, and public service program at UC Santa Cruz. Learn more at casfs.ucsc.edu, or contact casfs@ucsc.edu, (831) 459-3240. Additional Grower Guides are available online at casfs.ucsc.edu/about/publications.

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Photo, p. 1, left: Elizabeth Birnbaum. Illustrations, pp. 3 and 6, Laura Vollset.

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APPENDIX: PRODUCTION SCHEDULE, ECONOMIC DATA

Crop day	# beds (1 bed = .02ac)	Action	work rate (hr/ac)	fixed rate (hrs)	Total labor cost @ $16.10/hr	Total machine cost @ $21.70/hr	Harvest Week	% total harvest	Harvest Amt.	Harvest Value
-25	10	Flail Mow:heavy	2.50	0.2		$15.19				
-25	10	Spade	4.80	0.2		$25.17				
-11	10	Mark Lines	2.00	0.2		$13.02				
-11	10	List	1.25	0.2		$9.77				
-11	10	Overhead Irr:set up	3.75		$12.08					
-10	10	Overhead Irr:run		0.5	$8.05					
-1	10	Light cultivation	1.25	0.2		$9.77				
-1	10	Shape	2.00	0.2		$13.02				
0	10	Transplant:1 line	58.00	0.5	$194.81					
0	10	Overhead Irr:run		0.5	$8.05					
1	10	Overhead Irr:run		0.5	$8.05					
4	10	Overhead Irr:run		0.5	$8.05					
7	10	Overhead Irr:run		0.5	$8.05					
11	10	Overhead Irr:break down	3.75		$12.08					
11	10	Cultivate	2.00	0.2		$13.02				
11	10	Drip:set up	10.00	0.25	$36.23					
11	10	Hoe:1 line	36.00		$115.92					
12-169	10	Drip:run x 2/wk @ 22 weeks		0.3	$106.26					
35	10	Hand Weed:big weeds	8.00	0.2	$28.98					
65	10	Hand Weed:big weeds	8.00	0.2	$28.98					
120	10	Harvest x 2	532.40		$171.43		1	10%	799	$1,197.90
127	10	Harvest x 2	532.40		$171.43		2	10%	799	$1,197.90
134	10	Harvest x 2	532.40		$171.43		3	10%	799	$1,197.90
141	10	Harvest x 2	532.40		$257.15		4	15%	1,198	$1,796.85
148	10	Harvest x 2	532.40		$257.15		5	15%	1,198	$1,796.85
155	10	Harvest x 2	532.40		$342.87		6	20%	1,597	$2,395.80
162	10	Harvest x 2	532.40		$171.43		7	10%	799	$1,197.90
169	10	Harvest x 2	532.40		$171.43		8	10%	799	$1,197.90
175	10	Flail Mow:light	1.25	0.2		$9.77				
-	10	Drill/Cover Crop	1.60	0.2		$11.28				
				Sub-total:	$2,289.90	$120.00				

Labor + Machine Cost ($)	
Per Block (.2 Acres):	***$2,409.90***
Per Acre:	***$12,049.52***

Yield		
Per Block (.2 Acres):	**7,986**	***$11,979.00***
Per Acre:	**39,930**	***$59,895.00***

Harvest Assumptions	
Harvest (#/acre)	39,930
Harvest (#/row')	2.75
Harvest Rate (#/hr)	75
Harvest (hr/ac)	532.4
Price ($/#)	1.5

Item	*Cost per unit*	*Cost per acre*	*Notes*
Starts	$.025/plant	$363.00	1 row/bed; 14520 row'/ac; 1' spacing
Drip Tape	$120/7500'	$232.32	1 row/bed; 14520 row'/ac; $.016/row'
Boxes	$2.067/bx	$4,878.12	20#/box; 47190#/ac; 2360 box/ac
Total Expenses (per acre):		***$5,473.44***	

Per Acre Totals	
Income:	$59,895.00
Labor + Machine Cost ($)	-$12,049.52
Expenses	-$5,473.44
Production Profit:	**$42,372.04**

Complete irrigation schedule available online at casfs.ucsc.edu/about/publications/growerguides. Data reflect direct field production costs and do not include other potential overhead (e.g., water, electricity, land rent).