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

Introduction

Winter squash production can be done with low capital investment and simple infrastructure. Squash has low seed cost, modest fertility needs, and relatively little labor requirements during the growing season. The broad leaf canopy minimizes weed pressure, and many varieties are fairly resistant to pests and diseases. "Winter" or "hard" squash is grown in the warm season and can be stored for some months (through the winter). Unlike "summer" squash (zucchini and other "soft" squashes) that must be harvested daily and stored in a cooler, winter squash has a flexible window of harvest and sale (with proper dry storage). These characteristics make winter squash a viable crop for beginning specialty crop growers.

Growing a mix of varieties provides an assortment of colors, textures, and flavors to diversify marketing opportunities or add variety to a Community Supported Agriculture (CSA) program.

Depending on markets, varieties, and yields, winter squash can provide excellent cash returns. Adequate dry storage allows sales to be spread over a period of two to four months for best price.

This guide addresses the steps involved in growing winter squash organically on the Central Coast of California, with a focus on planting to moisture to minimize weed pressure.

Features of winter squash production

- Winter squash grows well in cooler coastal areas as well as the warmer inland valley locations (it has few climatic limitations in the Central Coast region)
- Requires little labor throughout the growing season
- Stores well with minimal infrastructure (dry storage only; no cooler needed), which is useful for extending direct sales/CSA season
- Resists or tolerates pests and diseases
- Grows well in most soil types and requires only moderate soil fertility levels
- Produces reasonable yields with relatively little irrigation; can be dry farmed in the right climate and soil type (see Dry-Farmed Tomato Grower Guide)
- Provides for excellent crop rotation to improve soil quality and decrease weed pressure for future crops

PRODUCTION PRACTICES — SUMMARY

Soil type and pH

- Does well on a range of soil types but grows best on well-drained sandy loam soil with pH 5.8 – 6.5.

Site selection

- Avoid planting where infestations of cucumber beetle have been heavy or common.
- Plant upwind and separated from older sequential blocks, and other crops highly susceptible to cucumber beetles, such as potatoes, cucurbits, beans and corn.

Fertility requirements

- Fall/winter cover crop (bell beans, triticale, vetch).
- Compost, as needed (5–7 tons/acre).
- Post-plant fertility may be needed on sandy soils with minimal residual fertility and low CEC (cation exchange capacity).

Soil temperature

- Optimum soil temperature is 60°F or higher at planting depth.

Amount of seed needed

- 2–3 lbs/acre.

Plants per acre

- 3,000 – 4,000 (vining types).
- 6,000 – 8,000 (bush types).

Planting date

- Mid May through early July, depending on variety.

Planting technique

- Sow directly into moisture.
- Plant in beds or on the flat.
- Can be transplanted (intensive garden system) but are rarely transplanted on a field scale system.

Plant and row spacing

- Bush types: 36–60" between rows; plants should be 24" apart.
- Vining types: 60–80" between rows; plants should be 36–48" apart.
- Plant closer and thin to the desired spacing in the row to ensure a uniform stand of healthy plants.

Planting depth

- Bush types (typically smaller seed size): up to 1" deep depending on soil type and depth to moisture
- Vining types (typically larger seed size): up to 2" deep depending on soil type and depth to moisture

Irrigation

- May be planted to moisture and dry farmed.
- If planted to moisture and irrigated, lay drip lines following the first cultivation and hold off as long as possible before the first irrigation.
- Note that some growers use overhead irrigation early in the production cycle to minimize powdery mildew.

Days to maturity

- 85–110 days depending on variety and weather conditions.

Harvest/Post-harvest handling

- Leave squash on vines until plants begin to senesce (die after maturing) .
- Cut squash with hand-held clippers, leaving a short stalk once foliage dies back and the tendril begins to dry (opposite the squash attachment stem on the main vine).
- Windrow in field to facilitate pick up.
- Store for short periods of time in cardboard bins.

Crop rotation

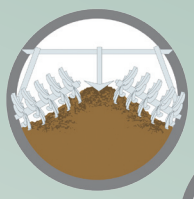
- Managed well, a winter squash crop will suppress weeds and scavenge fertility, making it a good crop to follow more intensive mixed vegetables that require higher fertility inputs. Few weeds grow or set seed among a squash crop that is planted to moisture and drip irrigated once full crop canopy is established. This reduces weed seed in that field, to the benefit of subsequent crops.
- Prepare fields with relative ease and minimal tillage for subsequent crops or cover crops; winter squash residue breaks down well.
- Where Verticillium wilt *(Verticillium dahliae)* is present, use long rotations (2–3 years or more) out of susceptible crops such as cucurbits, solanums, and strawberries to non-susceptible crops, such as grasses and legumes.

PRODUCTION SEQUENCE — OVERVIEW

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

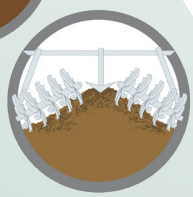
(crop day -25) Incorporate cover crop residue.

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



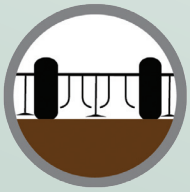
(crop day -10) Pre-irrigate beds with overhead irrigation (1–1.5"). Wait for dry down and weed emergence.

(crop day -1) Work bed surface lightly with cultivator to terminate weeds, re-form beds, and create "dust mulch" to trap subsoil moisture.



(crop day 0) Direct seed squash seeds with a JD 71 planter (or equivalent).**

(crop day 20) Cultivate for additional weed control using standard 3-bar cultivator with sweeps, knives, and disc hillers.



(crop day 21) Lay drip lines.

Apply drip irrigation once canopy forms and continue weekly.

Hand weed large weeds as needed.

(crop days 120, 140) Clip squash from vines, let cure in field.

(crop days 150, 160) Harvest.

Drill cover crop seed prior to fall/ winter rains.

Following harvest, prepare ground for subsequent planting or cover crops.

***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.

** On garden scale, plant transplants

Production Practices — Additional Details

Pre-plant fertility

A legume/cereal mix cover crop incorporated prior to bed preparation should provide adequate fertility for winter squash on most soil types. If additional fertility is required, apply high quality compost (5–7 tons/acre) at time of cover crop incorporation. Supplemental post-plant fertility is seldom needed, although winter squash grown on very low CEC (cation exchange capacity) sand with minimal residual fertility may require additional nutrients, which can be applied via drip injection.

Bed preparation and planting

Although winter squash can be planted "on the flat" (i.e., without forming beds), a bedded system improves moisture retention and weed management.

Perform standard tillage practices to incorporate crop or cover crop residue (Figure 1), break compaction, and adequately loosen soil. Then, form the planting beds using bedding shovels or a rolling cultivator.

If there is no rainfall following bed formation in the spring, pre-irrigate (1–1.5") with overhead irrigation to wet the root zone and germinate weeds prior to planting. This pre-irrigation further improves soil conditions and tilth by breaking down soil clods or clumps of cover crop residue, leaving the soil loose, moist, and friable.

Following the pre-irrigation (or spring rainfall of 1–2"), eliminate newly germinated weeds with a rolling cultivator or other suitable cultivation technique. If timing is good and the moisture is uniform, such a run can work wonders. This initial cultivation breaks surface crusting and provides a "soil mulch" to slow evaporative loss of deeper soil moisture.

Once crop or cover crop residue is adequately decomposed (residues brown, leaves no longer recognizable) and soil temperatures are above 60°F, use a suitable planter (see below) to push aside the drier soil on the bed tops and plant the squash seeds into the deeper moisture in the bed.

Timing of planting

In general, winter squash can be planted from mid-May through June on California's Central Coast. Shorter-maturing varieties can be planted in early July. Planting dates are based on timing of adequate seedbed preparation (allowing for thorough cover crop residue decomposition), soil moisture (adequate for germination), and optimal soil temperature (>60°F).

FIGURE 1. A spader can be used to incorporate cover crops. *Photo: Elizabeth Birnbaum*

FIGURE 2. John Deere 71 "flexi" planter. *Photo: Jim Leap*

Plant late enough in spring to allow for rapid plant growth; this will help limit cucumber beetle and other herbivore damage to seedlings. Planting dates must be early enough to allow the crop to mature and adequately field cure before fall rains, heavy dew, or frost.

Planting to moisture

Winter squash seed can be planted to moisture by hand with a shovel or trowel. There are also "seed stick" planters that are very effective for planting winter squash. Push planters such as the Planet Jr. are effective for garden-scale production, but require a special "deep" opening shoe to get the seed far enough into moist soil.

On larger field-scale blocks (>.25 acres), use a tractor-mounted planter such as the John Deere 71 "flexi" planter or other similar plate-type planter (Figure 2). The planter's double disc openers cut through residual cover crop or crop residue. Adjust planting depth with a rotating cam on the side of the planter, which changes the angle of the press wheel in relation to the disc openers. For mixed blocks (multiple varieties) of winter squash on relatively small plots, the planter hopper can be removed and the seeds hand dropped into the drop tube. This circumvents the need for multiple seed plates to match each variety.

Note that it is better to plant into soil on the drier side. On many soil types, if the soil is too wet at planting, soil surface crusting can impede successful crop emergence. Squash plants that struggle to break through crusted soil may remain stunted.

In cases when the soil is either too wet or too dry, you can form a "cap" of soil over the seed line to either minimize crusting (too wet) or to minimize further evaporative loss (too dry). Run soil cappers behind the planter to create a loose cap of soil right over the seed line behind the planter's pack wheel (Figure 3).

With optimum soil conditions (>60°F and minimal crusting) and planting depths, plants should emerge in 7–10 days. Uniform emergence is the best sign of optimal planting conditions and potential for a successful crop.

The most critical aspect of effectively "planting to moisture" is your ability to judge soil moisture and decide on seed depth. Decisions related to seed depth will vary depending on soil type, seed size, and weather and soil conditions at the time of planting. Because of the challenges associated with planting to moisture,

FIGURE 3. Soil cappers run behind the pack wheel create a loose "cap" of soil over the seed line. *Photo: Jim Leap*

less experienced growers may opt to irrigate up their newly planted squash seed. This practice is effective and will ensure a good stand, but results in more weed competition and management costs. Please see the publication *Tillage, Bed Formation, and Planting to Moisture* in this Grower Guide series for additional details.

Thinning

Thin winter squash to the desired spacing once plants are fully emerged and well established but still relatively small. As needed, weed in the plant line at the time of thinning (by hand or with a hoe).

Irrigation

Drip irrigation minimizes weed pressure, although some growers use overhead irrigation prior to fruit set to help control powdery mildew.

Timing of the first drip irrigation depends on the water-holding capacity of the soil, the initial soil preparation, the amount of winter rainfall, and the amount and timing of any pre-irrigation. Lay out drip lines when the plants have been thinned but are still small, and the first cultivation is complete (Figure 4). Delay irrigation as long as possible to encourage deep rooting of the squash plants. To minimize weed pressure, the first irrigation ideally would take place once squash leaves grow a full canopy to shade out weeds that may emerge once irrigation is initiated.

From this point on, use evapotranspiration (Et) estimates from your local CIMIS station (cimis.water.ca.gov) or another source to inform irrigation decisions. Irrigation rates will likely range from 1–2" per week for the duration of the crop's development. Once the squash fruits are sized there is no need for further irrigation and the water can be cut.

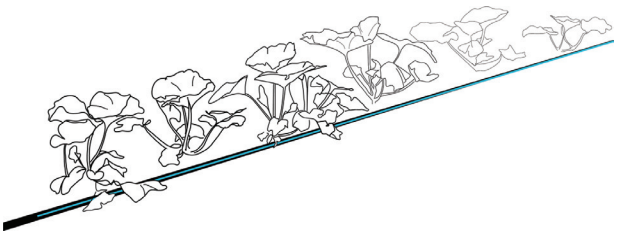


FIGURE 4. Lay drip tape when plants are still small, following first cultivation. *Illutration: Laura Vollset*

VARIETAL OVERVIEW: Popular winter squash varieties

Acorn ***(Cucurbito pepo)*****:** A small, green, thin-skinned type with sweet "caramelized sugar" flavor and smooth flesh. Short storage window (~1 month). To maintain best flavor and texture, skip field cure and bring them into cool storage once they have colored up. This type keeps best at slightly cooler storage than other winter squash. **VARIETIES: Sweet Reba, Table Queen, Carnival (Acorn x Sweet Dumpling)**

Delicata ***(C. pepo)*****:** A mild, sweet, early season, small (1–2 pounds), thin-skinned type with very sweet, smooth yellow flesh. As it ripens, color goes from white with green striping to pale yellow with orange and green striping. Storage life is longer than acorn but become drier and starchier in the 2nd–3rd month of storage. Skin is edible. **VARIETIES: Zeppelin Delicata, Sweet Dumpling**

Butternut ***(C. moschata)*****:** A bell-shaped fruit with thin tan skin. Widely grown for its bright orange, sweet, moist flesh, this type has a long storage life (~6–8 months), and seems to get better with age. **VARIETY: Waltham**

Spaghetti ***(C. pepo)*****:** A large, oblong fruit. The pale yellow flesh is quite mild, only slightly sweet, and breaks apart to look like strands of spaghetti when cooked. It has a short storage life (~4–6 weeks).

Hubbard ***(C. maxima)*****:** A large, hard-skinned, tear drop-shaped type with several color varieties, from pale blue to bright orange skin, with pale yellow to deep orange flesh, which is sweet and savory. Great as a pie filling or puree. Can be stored up to 6 months in proper conditions. **VARIETIES: Red Kuri, Blue Ballet**

Kabocha ***(C. maxima)*****:** A squat-shaped Japanese type with rough, thick skin in several colors, with dark green most common, but also in shades of gray to light blue, or bright orange. The flesh is distinctively dry and flaky with a rich, nutty flavor. Long storage life (~6–8 months). **VARIETIES: Sunshine (bright orange-red), Cha-Cha (dark green)**

Buttercup ***(C. maxima)*****:** Compact and green, closely resembles a kabocha type, but is distinguished by a round ridge on the bottom. The flesh is dense, firm, and somewhat dry. **VARIETIES: Burgess, Bush** ***(compact plants, good for garden scale)***

NOTE that some varieties are resistant to powdery mildew, a major disease of winter squash. When you search seed catalogs, look for the abbreviations "PMT" for Powdery Mildew Tolerant.

Clockwise from top left: Red Kuri, Winter Luxury (pumpkin), Sweet Reba, Zeppelin, Sunshine. *Photo: Elizabeth Birnbaum*

FIGURE 6. The squash canopy shades out weeds as fruit develops.
Photo: Elizabeth Birnbaum

Winter squash commonly show signs of wilting on hot afternoons. This is not always related to lack of available water, so don't use the afternoon wilt symptom as a guide for irrigation frequency. If the plants appear wilted in the morning, then the plants are water stressed and you need to irrigate.

Weed control

When squash seeds are planted to moisture, late season rains are minimal, and drip irrigation can be delayed until there is a full canopy of leaves between plants within the row, there may be no weeding necessary during the entire cropping cycle. This type of management can significantly reduce production costs, keep the field clean of unnecessary weed seed, and maintain profitability.

If between-row weed management is needed after thinning and in-row weeding, use a three-bar cultivator mounted with disc hillers, sweeps, and knives. Because of the low growing point of squash plants, it is not advisable to move soil towards the plant following emergence. Rolling cultivators are therefore not an appropriate tool to effectively manage weeds in winter squash.

Run shallow chisels behind the tractor tires to break tractor tire wheel compaction, especially in situations where soil moisture is high at the time of cultivation. This will aid fall tillage and minimize clod formation. Generally, only one or two cultivations are needed for weed management in winter squash. The few weeds that escape cultivation can be hand pulled once the squash is in full bloom. After that, the canopy should prevent further weed germination or growth (Figure 6). Additional passes may be needed to control bindweed or other perennial weeds.

Harvest

Color is probably the best indicator of harvest timing. Most varieties will develop a deep color as the stems dry down, the rind loses its sheen, and the fruit hardens. For example, Butternut will go from light green to deep tan; Sweet Dumpling and Delicata will go from white/green to deep yellow/orange

Once the squash foliage has fully senesced, cut the squash from the vine with hand-held clippers, leaving a short stalk on the fruit. Take care not to break off the stem as early post-harvest decay can develop at the point of detachment. Windrow the harvested squash in the field to facilitate pick up after curing (Figure 7). Field curing—leaving squash in the sun for 1–2 two weeks (depending on weather)— allows fruit to shed some moisture, concentrates sugars, hardens the skin, and slows respiration, allowing for better long-term storage. Curing for more than two weeks may cause sunburn and make fruit susceptible to insect damage. If rain or a heat wave (temperatures over 95°F) is forecast, squash should be picked up and stored.

Cardboard bins may be used for field removal and temporary storage. Handle squash carefully to avoid cutting or bruising the skin. Remove dirt from squash and cull damaged fruit while filling bins; do final quality assessment and grading when packing boxes from the bins for market. Bins on pallets may be moved with a three-point forklift attachment on a tractor, or a forklift. Store squash in a shady, covered area.

Post-harvest considerations

When kept dry and rodent free, most winter squash varieties will store well at ambient temperatures for 2–5 months, and some varieties (e.g., Butternut, Hubbard) will store for up to 8 months or longer. Consult seed catalogues and post-harvest storage charts (see Additional Resources) for optimal storage temperatures of the squash varieties you grow.

Post-harvest field care

Shortly after harvest, retrieve all drip lines and prepare the ground for a subsequent cash crop or winter cover crop. Mow the squash vines after harvest to eliminate large clumps of plant material prior to discing. If left intact, large vine pieces can cause "wrapping" and "gathering" problems with some follow-up tillage implements (e.g., chisels and spring tooth harrows).

Because squash requires minimal tractor and foot traffic on moist ground during the cropping cycle, the soil should be easy to work following harvest. Typically the winter squash field will only need mowing and one or two passes with a disc to adequately prepare the ground for planting. Optimal soil conditions support good cover crop stands and rainwater infiltration rates.

FIGURE 7. Windrowed winter squash curing at the UCSC Farm.
Photo: Elizabeth Birnbaum

DRY FARMING WINTER SQUASH

Many varieties of winter squash are well suited to dry farming in California's Central Coast region, especially in areas with marine influence and generally cooler daytime highs. Primary considerations for dry farming winter squash include:

- Minimum 20" of winter rainfall.
- Deep soils with high clay content in lower horizons.
- Timely (early) incorporation of cover crop to minimize loss of deeper soil moisture due to transpiration by the cover crop.
- Tillage practices that promote water holding and minimize loss of moisture through surface evaporative.
- Use of wider-than-standard plant spacings to allow for greater soil/water volume for each plant. Wider spacing means fewer plants and lower yields.

Pests and Diseases

Before you select varieties and plant your winter squash crop, look up common pests and diseases that affect the crop in your area. Learn about pest and disease life cycles, preventive 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 winter squash arthropod pests in the Central Coast region are:

- Cucumber beetle: Western spotted cucumber beetle, *Diabrotica undecimpunctata undecimpunctata*; Western striped cucumber beetle, *Acalymma trivittatum*: feed on foliage and fruit.
- Melon Aphid, *Aphis gossypii* and other aphids: transmit plant viruses, feed on leaves of older plants, honeydew can lead to mold infections.

The main winter squash diseases in the Central Coast region are:

- Powdery mildew: *Sphaerotheca fuliginea* (=*Podosphaera xanthii*) and *Erysiphe cichoracearum* (=*Golovinomyces cichoracearum*): affects leaves and stems of older, fruit-bearing plants.
- Verticillium Wilt, *Verticillium dahliae*: interferes with water transport, can reduce fruit yield and quality, or kill plant.

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 in winter squash.

ADDITIONAL RESOURCES

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

Organic pumpkin and winter squash marketing and production, by Janet Bachmann and Katherine Adam. NCAT IP371, 2010. attra.ncat.org/attra-pub/summaries/summary.php?pub=30

Powdery mildew resistant winter squash varieties are valuable addition to management program. Vegetable MD Online, Cornell University. vegetablemdonline.ppath.cornell.edu/NewsArticles/Winter_PM_Resistant.html

UC Davis postharvest technology postharvest.ucdavis.edu/Commodity_Resources/Fact_Sheets/(see Pumpkins)

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

This publication was supported by the Specialty Crop Block Grant Program at the U.S. Department of Agriculture (USDA) through Grant 14-SCBGP-CA-0006. Its contents are solely the responsibility of the authors and do not necessarily represent the official views of the USDA. Mention of commercial products does not constitute an endorsement.

Photos, p. 1: Elizabeth Birnbaum. Icon illustrations, p. 3, Laura Vollset.

CASFS The CENTER for AGROECOLOGY & SUSTAINABLE FOOD SYSTEMS

1156 High Street
Santa Cruz, CA 95064
casfs@ucsc.edu
casfs.ucsc.edu

APPENDIX: PRODUCTION SCHEDULE, ECONOMIC DATA

Crop day	sub crop	# beds (1 bed = .02ac)	Action	work rate (hr/ac)	fixed rate (hrs)	Total labor cost @ $16.10/hr	Total machine cost @ $21.70/hr	Harvest Amt.(#)	Harvest Value($)
-25		10	Flail Mow:heavy	2.5	0.2		$15.19		
-25		10	Spade	4.8	0.2		$25.17		
-11		10	Mark Lines	2	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	JD 71 Seed	4.82	0.2		$25.26		
0		10	Plant:drop seeds	9.64	0.2	$34.26			
18		10	Thin plants	2		$6.44			
20		10	Cultivate	2	0.2		$13.02		
21		10	Drip:set up	10	0.25	$36.23			
21-119		10	Drip:run x 1/wk; @ 15wks		2.25	$36.23			
45		10	Hand Weed:big weeds	8	0.2	$28.98			
70		10	Hand Weed:big weeds	8	0.2	$28.98			
120	Red kuri	2	Clip	6		$3.86			
120	Delicata	4	Clip	6		$7.73			
140	Butternut	4	Clip	6		$7.73			
150	Red kuri	2	Harvest	37.23		$23.98		1,162	$871.20
150	Delicata	4	Harvest	14.17		$18.25		884	$663.00
160	Butternut	4	Harvest	23.27		$29.97		1,452	$1,089.00
			Pack						
-		10	Drill/Cover Crop	1.6	0.2		$11.28		
					Sub-total:	$282.75	$122.47		

Harvest Assumptions	
Harvest (#/acre)	
Delicata	18,000
Butternut	29,000
Red Kuri	22,000
Harvest (#/hr)	780
Harvest Rate (hr/ac)	
Delicata	14.17
Butternut	23.27
Red Kuri	37.23
Price ($/#)	0.75

Labor + Machine Cost ($)	
Per Block (.2 Acres):	*$405.23*
Per Acre:	*$2,026.15*

Yield		
Per Block (.2 Acres):	*3498*	*$2,623.20*
Per Acre:	*17488*	*$13,116.00*

Item	Cost per unit	Cost per acre	Notes
Drip Tape	$120/7500'	$232.32	1 row/bed; 14520 row'/ac; $.016/row'
Seeds	-	$200.00	Seed cost per acre: butternut $70; Delicata $140; Red Kuri $580
Boxes	$.98/box	$490.00	.98/bx; 35#/box; 500 box/ac
Total Expenses (per acre):		*$922.32*	

Per Acre Totals	
Income:	$13,116.00
Labor + Machine Cost:	-$2,026.15
Expenses:	-$922.32
Production Profit:	**$10,167.53**

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).