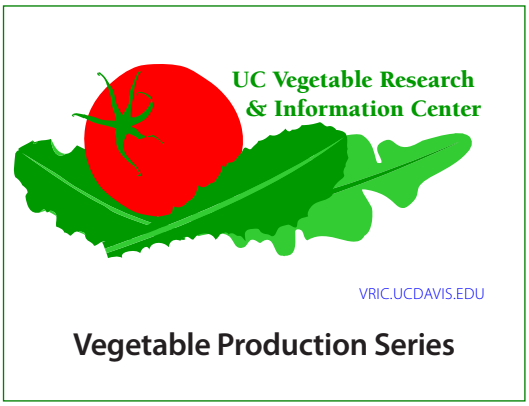

CELERY PRODUCTION IN CALIFORNIA

OLEG DAUGOVISH, *University of California Cooperative Extension Farm Advisor, Ventura County;* **RICHARD SMITH**, **MICHAEL CAHN**, *and* **STEVE KOIKE**, *University of California Cooperative Extension Farm Advisors, Monterey County;* **HUGH SMITH**, *University of California Cooperative Extension Farm Advisor, Santa Barbara County;* **JOSÉ AGUIAR**, *University of California Cooperative Extension Farm Advisor, Riverside County;* **CARLOS QUIROS**, *Professor, Department of Plant Sciences, University of California, Davis;* **MARITA CANTWELL**, *University of California Cooperative Extension Vegetable Specialist, University of California, Davis; and* **ETAFERAHU TAKELE**, *University of California Cooperative Extension Area Advisor Farm Management/Agricultural Economics, Riverside County*

PRODUCTION AREAS AND SEASONS

The two main growing regions for celery (*Apium graveolens* L.) in California are located along the Pacific Ocean: the south coast (Ventura, Santa Barbara, and San Luis Obispo Counties) and the central coast (Monterey, San Benito, and Santa Cruz Counties). A minor region is located in the southern deserts (Riverside and Imperial Counties).

On the south coast, celery is transplanted from early August to April for harvest from November to mid-July; in the Santa Maria area, celery is transplanted from January to August for harvest from April through December. On the central coast, fields are transplanted from March to September for harvest from late June to late December. In the southern deserts, fields are transplanted in late August for harvest in December to March.

CELERY ACREAGE AND VALUE

Year	Acreage	Average yield (ton/acre)	Gross value/ acre
2005	25,400	35.5	$10,084
2004	25,700	35.5	$10,644
2003	25,300	35.8	$9,538
2002	25,000	35.5	$9,016

Source: California Agricultural Resource Directory 2006 (Sacramento: California Department of Food and Agriculture, 2006).

CLIMATIC REQUIREMENTS

Celery is a cool-season biennial that grows best from 60° to 65°F (16° to 18°C), but it will tolerate temperatures from 45° to 75°F (7° to 24°C). Freezing damages mature celery by splitting the petioles, making the stalks unmarketable. This is a major problem in plantings in the southern deserts. However, celery can tolerate minor freezes early in the season.

VARIETIES AND PLANTING TECHNIQUES

Most of the varieties grown today (Command, Mission, and Challenger) are resistant to Fusarium yellows, a major disease of celery. Other popular varieties are Conquistador, Sonora, and Matador, but these are recommended only for soils with low incidence of Fusarium yellows, since they have only some tolerance to the disease. Several shippers use their own proprietary varieties.

Celery seed is very small and difficult to germinate. All commercial celery is planted as transplants grown in greenhouses and nurseries. Celery grown from transplants is more uniform than that grown from seed and takes less time to produce a crop in the field. Transplanted celery is planted in double rows on 36- to 40-inch (91- to 100-cm) beds, with plants spaced 9 inches (22.5 cm) apart and plant rows 14 inches (36 cm) apart.

SOILS

Clays, clay loams, and loams that have good drainage and a high water-holding capacity have traditionally been preferred for growing celery. With the introduction of drip irrigation, celery production is now common on lighter-texture soils because uniform soil moisture can be maintained. For succulent, high-quality stalks, celery requires high-fertility soils.

IRRIGATION

Celery is a shallow-rooted crop that requires frequent irrigations. It is irrigated using overhead sprinklers, drip, or flood (furrow), or a combination of these methods. Celery transplants are usually sprinkler-irrigated from planting until the first side-dressing of fertilizer. Herbicides are often applied in the first sprinkler application. Many growers continue to

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http://anrcatalog.ucdavis.edu
Publication 7220

use sprinklers after establishing transplants, or they use a combination of furrow irrigation and sprinklers. Overhead sprinklers permit more-frequent and lighter irrigations than can be achieved with furrow irrigation. Furrow irrigation may provide better uniformity than sprinklers in regions with windy conditions or when plants exceed the height of the sprinkler risers. Surface-placed drip has become a major method of irrigating celery in recent years, and a small but increasing acreage of celery transplants in Ventura County is being established and grown exclusively with drip irrigation. Surface drip systems are usually installed after the first cultivation and side-dressing; they permit growers to water frequently during rapid vegetative growth. The drip lines are typically retrieved before harvesting. Drip irrigation can distribute water more uniformly than furrow or sprinkler irrigation. It has helped growers attain uniform growth in fields with variable soil textures by maintaining high soil moisture levels in all areas of the field. Drip can be managed to minimize the leaching of nitrate nitrogen (NO_3-N) by fertigating weekly with low rates of fertilizer and applying less water more frequently than can be achieved with sprinkler or furrow systems. For tender, succulent stalks, high soil moisture is necessary near harvest. Growers sometimes supplement drip-irrigated fields with water from sprinkler or furrow systems to saturate the entire bed 1 to 2 weeks before harvest. Soil allowed to become too dry can cause a calcium deficiency in celery known as blackheart. Water stress may contribute to pith, a physiological disorder characterized by spongy tissue at the base of the petiole, while overwatering can promote development of diseases such as pink rot and crater rot.

The water requirements of celery depend on the irrigation method, weather conditions, and soil type. Celery grown with furrow irrigation and overhead sprinklers uses approximately 2.5 to 3.5 acre-feet (3,083 to 3,700 m^3) of water. A combination of sprinkler and drip irrigation uses from 1.5 to 2.5 acre-feet (2,096 to 2,466 m^3) of water. An additional 4 to 6 inches of water is frequently applied before planting to moisten soil for chiseling and bed listing. Soil moisture monitoring and weather-based irrigation scheduling can be used in combination to determine the water needs of celery. Celery uses the highest amount of water during the last month before harvest, when vegetative growth is high. Maintaining soil moisture tension below 30 cbars (0.03 MPa) by frequent irrigations during the last few weeks of the crop usually maximizes yield. The water extraction of celery can be estimated using reference evapotranspiration data adjusted for a crop coefficient that is closely related to the percentage of canopy cover. The California Irrigation Management Information System (CIMIS, wwwcimis.water.ca.gov), coordinated by the California Department of Water Resources, provides daily estimates of reference evapotranspiration for most production regions of California.

FERTILIZATION

Celery is the most demanding of the cool-season vegetables for nutrients, and care must be taken to provide adequate nutrition to the crop. However, soils in the central and south coast regions can have elevated levels of NO_3-N and phosphorus (P), which can cause elevated levels of these nutrients in runoff; this makes it difficult for growers to comply with water quality standards established by the regional water quality control boards. As a result, application of these nutrients must be carefully managed.

Seasonal phosphorus uptake by celery ranges from 40 to 45 pounds of phosphorus per acre (45 to 50 kg/ha). Phosphorus fertilization should be based on the soil test level of bicarbonate-extractable phosphorus. Levels above 60 ppm are adequate for growth; for soils below this level, especially in the winter, preplant applications of 40 to 80 pounds per acre (45 to 90 kg/ha) of P_2O_5 are recommended. Potassium uptake by celery ranges from 350 to 450 pounds per acre (390 to 504 kg/ha). The need for potassium can also be determined from soil tests; soils with greater than 150 ppm of ammonium-acetate-exchangeable potassium have sufficient quantities of potassium for the crop. Potassium fertilization presents no environmental risk, and many growers routinely apply potassium even in fields with high exchangeable soil potassium. Fertilizing to replace potassium removal by the harvested crop (approximately 350 to 450 pounds per acre) is appropriate to maintain soil fertility.

Fall application of nitrogen (N) is not recommended due to the risk of NO_3-N leaching beyond the root zone by the winter rains. High-yielding celery typically takes up 200 to 250 pounds of nitrogen per acre (224 to 280 kg/ha), and fertilization rates in fields under conventional irrigation reflect the fact that celery is a heavy nitrogen user. Small quantities of nitrogen, 20 to 30 pounds per acre (22 to 34 kg/ha), are applied pretransplant and can supply the young plants for the first month of growth. In many celery fields drip tape is installed within the first month following transplanting; it is common for growers to top-dress fertilizer under the drip tape. Given the small size of the celery at this time, small quantities of nitrogen can supply crop needs. The need for nitrogen by the crop increases as the crop matures. For instance, at 8 weeks before harvest the crop requires 15 to 20 pounds of nitrogen per acre per week (17 to 22 kg/ha); nitrogen demand peaks at 2 weeks prior to harvest, at 35 pounds of nitrogen per acre per week (39 kg/ha). In most field conditions, a seasonal fertigation total of

150 to 225 pounds of nitrogen per acre (168 to 252 kg/ha), or 200 to 275 pounds of total nitrogen per acre (224 to 308 kg/ha) including preplant and/or topdress nitrogen, should be adequate to maximize celery yield and quality, assuming efficient drip irrigation management. Celery planted later in the season, after other vegetables such as lettuce and cole crops, may benefit from substantial amounts of nitrogen left behind by the earlier crop. This nitrogen source can be measured by the presidedress soil nitrate test (PSNT); soil nitrate levels greater than 20 ppm in the top 12 inches (30 cm) are adequate for crop growth. The test can be repeated later in the season to ensure continuing nitrogen sufficiency. Zinc fertilization is recommended if the DTPA-extractable soil level is less than 1.5 ppm. Zinc fertilization is commonly practiced on the central coast due to high soil phosphorus levels, which reduce zinc uptake by plants.

INTEGRATED PEST MANAGEMENT

For detailed information about integrated pest management for celery, see the UC IPM Pest Management Guidelines for Celery Web site, http://www.ipm.ucdavis.edu/PMG/selectnewpest.celery.html. Herbicides, insecticides, and fungicides should always be used in compliance with label instructions.

Weed Management

Integrated weed management should be practiced prior to celery transplanting. Such management steps include crop rotation, removing weeds before they produce seed, preplant irrigation and disking to germinate and kill weed seedlings, timing the planting date to reduce weed impact, careful preparation and spacing of beds, and precise planting of transplants so that cultivating tools can be accurately aligned. For celery, weed control is most critical until transplants are established and begin to form a plant canopy that can shade out weeds. Preplant and postplant herbicides are available for use on celery; consult your local UCCE Farm Advisor, as approved chemicals change often. Subsequent cultivation by tractor and hand-weeding may also be necessary. Weeds of concern include little mallow *(Malva parviflora)*, redroot pigweed *(Amaranthus retroflexus)*, yellow nutsedge *(Cyperus esculentus)*, johnsongrass *(Sorghum halepense)*, and bermudagrass *(Cynodon dactylon)*, depending on the region and the time of year. In the Coachella Valley, velvetleaf *(Abutilon theophrasti)* is a common weed that is difficult to control in celery fields.

Insect Identification and Management

The most damaging insect pests of celery are caterpillars, aphids, and leafminers, depending on the region and time of year. In the central coast region, the pea leafminer *(Liriomyza langei)* is the most important pest. In southern production areas, the serpentine leafminer *(L. trifolii)* is the most important pest. The vegetable leafminer *(L. sativae)* can also attack celery in coastal areas. The primary damage is caused by larvae, which feed on the plant mesophyll, forming mines. Leafminer larvae are attacked by several species of parasitic wasp, which help suppress leafminer populations if insecticides do not interfere with their activity. Control strategies should be aimed at the larvae, not the more mobile, insecticide-resistant adults. Beet armyworm *(Spodoptera exigua)* can be a major pest in southern and central coast growing areas. Armyworms have many natural enemies and should be managed by using selective materials to avoid making other insect problems more severe. Rotation of insecticides with differing modes of action to slow insecticide resistance should always be practiced. The central and south coastal regions also face problems from the black bean aphid *(Aphis fabae)* and the lygus bug *(Lygus hesperus)*, which may severely damage early-season celery when adults migrate from drying native vegetation.

Disease Identification and Management

Greenhouse transplants can become diseased with late blight *(Septoria apiicola)* and bacterial leaf spot *(Pseudomonas syringae* pv. *apii)*. These diseases can result in weakened transplants. Once planted in the field, bacterial blight usually does not persist, and control measures are not needed. However, transplants infected with late blight can result in crop loss in the field if conditions favor disease development. Manage late blight by using pathogen-free seed, fungicides on transplants, fungicides in field plantings, and drip or furrow irrigation rather than overhead sprinklers. Early blight *(Cercospora apii)* is another foliar disease that is much less common in California and not as destructive as late blight.

Pink rot *(Sclerotinia sclerotiorum)* and crater rot *(Rhizoctonia solani)* are two soilborne fungal diseases that can affect the lower portion of the celery petioles if wet conditions are present. Fungicides are sometimes needed for control. Fusarium yellows *(Fusarium oxysporum* f. sp. *apii)* is a devastating soilborne fungal disease that can significantly reduce yields. The pathogen is a long-term resident in infested soils, so crop rotations are not effective. Control is achieved only by using resistant or tolerant cultivars. Sclerotinia petiole and crown rot *(Sclerotinia minor)* has been recently identified in southern California celery fields rotated with lettuce.

Although celery is susceptible to the aster yellows mycoplasma and the western celery mosaic (CeMV) and cucumber mosaic (CMV) viruses, commercial plantings are rarely impacted by these pathogens.

HARVESTING AND HANDLING

Celery is primarily hand-harvested, although some mowing machines cut celery for processing plants. Because of uniform crop growth, celery fields are cut only once. Fresh-market celery is graded according to the number of heads per carton (24, 30, 36, and 48) and field-packed into 60-pound (27.2-kg) cartons. Additionally, 28-pound (12.7-kg) cartons are used for harvesting hearts (head centers, placed in polyethylene bags). Cartons are cooled at distribution centers by forced air or hydrocooling and kept in cold storage until shipped. Celery is also harvested for lightly processed products (celery sticks, diced, or sliced) and for soup and other cooked products.

POSTHARVEST HANDLING

Celery is stored at 32º to 35ºF (0º to 2ºC) at a relative humidity of 98 to 100 percent. Caution must be used to prevent crushing of celery cartons. Careful stacking of cartons in a vertical position is important. Celery may absorb odors from other commodities such as apples, carrots, onions, and pears and should not be stored near them.

MARKETING

California produces about 75 percent of the nation's celery crop, followed by Florida and Texas. The majority of the crop is used for fresh market; lightly processed and processed products are also marketed. Substantial shipments are made throughout the year; however, heaviest production occurs in fall and midwinter. Prices fall during the heavy production period. Prices range from an average low of $238 per ton to an average high of $351 per ton during 2003–2005 (Los Angles Terminal Market prices). California exports celery to Canada and Taiwan. During 2003–2005, exports averaged 15 percent of the total production. Canada is the main export destination, averaging 14 percent (123,850 tons, or 112,332 metric tons) of the total production during the same period. The other export market, Taiwan averaged 8,272 tons (7,503 metric tons) and has been showing increasing consumption.

COSTS OF PRODUCTION

The costs of producing celery depend on the location. Celery is one of the high-cost crops in the coastal regions of Southern California. It is labor-intensive, especially in harvesting and postharvest handling. For more information, see *Celery Production: Sample Costs and Profitability Analysis* (ANR Publication 8028), at the ANR CS Web site, http://anrcatalog.ucdavis.edu/SampleProductionCostsProfitabilityAnalysis/8028.aspx.

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University of California
Agriculture and Natural Resources
Communication Services
6701 San Pablo Avenue, 2nd Floor
Oakland, California 94608-1239

Telephone 1-800-994-8849 or (510) 642-2431
FAX (510) 643-5470
E-mail: danrcs@ucdavis.edu

Publication 7220
ISBN-13: 978-1-60107-618-2

This publication has been anonymously peer reviewed for technical accuracy by University of California scientists and other qualified professionals. This review process was managed by the ANR Associate Editor for Vegetable Crops.

pr-11/08-SB/CR