



# ARTICHOKE PRODUCTION IN CALIFORNIA

**RICHARD SMITH**, *University of California Cooperative Extension Farm Advisor, Monterey, Santa Cruz, and San Benito Counties*; **AZIZ BAAMEUR**, *University of California Cooperative Extension Farm Advisor, Santa Clara, San Benito, and Santa Cruz Counties*; **MOHAMMAD BARI**, *Artichoke Research Association*; **MICHAEL CAHN**, *University of California Cooperative Extension Farm Advisor, Monterey, Santa Cruz, and San Benito Counties*; **DEBORAH GIRAUD**, *University of California Cooperative Extension Farm Advisor, Humboldt County*; **ERIC NATWICK**, *University of California Cooperative Extension Farm Advisor, Imperial County*; and **ETA TAKELE**, *University of California Cooperative Extension Farm Advisor, Riverside County*

## PRODUCTION AREAS AND SEASONS

The major California production areas for artichokes (the globe artichoke, *Cynara scolymus*) are the central coast (Monterey, Santa Cruz, and San Mateo Counties); south coast (Santa Barbara, Ventura, Orange, and San Diego Counties); desert (Riverside and Imperial Counties); and the Central Valley.

On the central coast, artichokes are grown year-round as perennials. The peak production of perennials occurs from March to April. Following harvest, plants are mowed and then cut back at ground level to encourage regrowth and to manipulate the timing of harvest. In other parts of the state, artichokes are grown as annuals: artichoke seed is planted in greenhouses and transplanted into the field to time production to meet market demand. On the central coast, annual artichokes are transplanted from November to June for harvest from April to October. In the desert production areas, artichokes are planted from August to October for harvest from December to April.

## ARTICHOKE ACREAGE AND VALUE

Year	Acreage	Average yield (ton/acre)	Gross value/acre
2006	7,900	4.75	\$4,040
2005	7,900	5.50	\$4,994
2004	7,500	5.50	\$4,961

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

## CLIMATIC REQUIREMENTS

Artichokes are a cool-season crop that grows best in 75°F (24°C) days and 55°F (13°C) nights. The temperature range for a good crop is from 85°F (29°C) to 45°F (7°C). In areas with cool day and night temperatures (i.e., cool coastal climates), the period of flower bud induction is extended, thereby lengthening the produc-

tion period. Plants are tolerant of temperatures above 86°F (30°C), but the quality of the edible flower bud is reduced. Freezing damages bud bracts, causing blistering of the outer bud tissue and a whitish appearance. Freezing injury is superficial and does not affect eating quality, but it does make discolored buds more difficult to market. Mature plants usually survive heavy frosts, but their yield may be reduced.

## VARIETIES AND PLANTING TECHNIQUES

### Varieties

The vegetatively propagated perennial variety Green Globe accounts for over half of the artichoke production in California. Seeded artichoke varieties include Imperial Star, Desert Globe, Emerald, Big Heart, and Green Globe Improved. Some larger commercial companies have developed their own varieties.

### Perennial Planting

The primary growing area for perennial artichokes in California is close to the coast. Perennial artichokes are propagated by division of the crown. Rooted sections of crowns ("stumps") selected from commercial fields are planted by hand in trenches 4 to 6 inches (10 to 15 cm) deep with 3.3 to 3.5 feet (1.0 to 1.1 m) in-row spacing and 9 to 10 feet (2.7 to 3.0 m) between rows. The plants are usually laid out in a grid system to make weeding and other operations easier. Growers generally replant a field every 5 to 10 years, because after years of regrowth, the rooting area becomes crowded and the plants tend to lose vigor. The cropping cycle for perennial artichokes begins when plants are cut back. For fall, winter, and spring harvests, the plants are cut back from mid-April to mid-June; for harvest in summer, they are cut back in late August or September. The plants are cut at ground level to stimulate new shoot development. During the harvest season, old bearing stalks are often



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Publication 7221

removed after the artichokes have been harvested to encourage the development of new shoots. This process, called “stumping,” consists of harvesters chopping out the stalk just below the ground using a hand axe or stalk knife. Stalks are removed at 3- to 4-week intervals throughout the year, depending on the growth of new bud-bearing stalks. Stumping is generally thought to increase total yield and extend the productive life of the field.

## Annual Planting

Artichokes grown as annuals are established by seed in greenhouses and then transplanted to the field. Bed widths vary from 72 to 80 inches (1.8 to 2.0 m); a single row of plants is used, with in-row spacing of 30 inches (76 cm). Annual plantings can fill market niches, as they can be timed to mature at different times of the year. The time from transplanting to maturity can vary from 4 to 6 months, depending on when transplanting takes place. Seeded artichokes can be grown in many parts of the state. In some parts of the state annual artichokes are direct seeded, but in general the majority of production is transplanted to avoid problems with weeds and diseases.

## SOILS

Artichokes can develop root systems down to 3 to 4 feet (90 to 120 cm) deep. They can be grown on a wide range of soils but produce best on deep, fertile, well-drained soils. Lighter soils that have excessive drainage and poor moisture-holding potential should be avoided. Artichokes are moderately salt tolerant. Research has shown bud yield reductions starting at soil salinity levels of 6 dS/m (ECe in mmho/cm at 25°C) and a reduction in vegetative growth at 7 dS/m. Yield losses are approximately 11 percent for each increase of 1 dS/m of soil salinity above these thresholds. Artichokes can tolerate boron levels in water from 2 to 4 ppm.

## IRRIGATION

Artichokes require adequate soil moisture during the vegetative and reproductive growth phases. Too little soil moisture, particularly when buds are forming, results in loose buds and poor quality. Moisture stress may also contribute to black tip, a physiological disorder that causes bracts to become dark brown, rendering them unmarketable. Artichokes are susceptible to root rot, and irrigation must be carefully managed to avoid saturating the soil. Ditches are dug in perennial artichokes during the winter to drain excessive rainwater.

Irrigation begins about 1 month after plants are cut back at the beginning of a new production cycle for perennial artichokes on the central coast. Early irrigations are typically provided by overhead sprinklers.

Subsurface drip, buried at 12 to 14 inches (30 to 35 cm) below the soil surface, often provides irrigations during the remainder of the production period; some growers use a single buried drip line in the plant row or two buried drip lines, one on either side of the plant row. On hilly terrain, pressure-compensating drip tape is used to attain high distribution uniformity. Annual plantings are usually established with overhead sprinklers. Growers often switch to surface-placed drip after the crop is established. The tape is retrieved after harvest and reused for subsequent crops.

During the summer on the central coast, sprinkler-irrigated plants are watered at 2- to 3-week intervals, depending on the soil type. Drip-irrigated crops are irrigated at closer to 1-week intervals, depending on the weather. Approximately 2 to 3 acre-inches per acre (206 to 310 m<sup>3</sup>) of water are applied by sprinklers with each irrigation to perennial crops; approximately 18 to 24 acre-inches per acre (1860 to 2480 m<sup>3</sup>) of water are applied for the entire crop per year depending on winter rainfall, which averages 16 inches (40 cm) per year in northern Monterey County. Although grown for a shorter time than perennial plantings, annual crops receive from 20 to 24 acre-inches per acre (2,060 to 2,480 m<sup>3</sup>) due to their denser canopy. Drip irrigation may reduce water use by as much as 25 percent on clay loam soils, and it has increased yields on sandy soils by maintaining higher soil moisture levels through more frequent irrigations than could be achieved with sprinklers. Water used for irrigation should be suitable for artichoke production and be appropriate for the irrigation system. High bicarbonate levels (> 4 meq/L) and high iron and manganese levels (> 0.5 ppm) in groundwater can form precipitates that plug drip emitters and reduce the system uniformity.

The combination of soil moisture monitoring and weather-based irrigation scheduling can be used to determine the water needs of artichokes. Water use is highest during summer months and when canopy cover has reached maximum size. Because of their deep root system, perennial crops can tolerate some water stress in the early vegetative phase, but crops should be adequately watered during flowering and bud formation. Water extraction by artichokes can be estimated using reference evapotranspiration data adjusted by a crop coefficient that is closely related to the percentage of ground covered by the canopy. At maximum canopy cover (> 90% canopy cover for annual plantings), the crop coefficient is nearly 1.0 for annual artichokes. The California Irrigation Management Information System (CIMIS, [www.cimis.water.ca.gov](http://www.cimis.water.ca.gov)), coordinated by the California Department of Water Resources, provides daily estimates of reference evapotranspiration for most production regions of California.

## FERTILIZATION AND PLANT GROWTH REGULATION

Soils in the central coast and south coast regions can have high levels of nitrate-nitrogen (NO<sub>3</sub>-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 regional water quality control boards. As a result, application of these nutrients must be carefully managed.

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, or plantings during the winter, preplant applications of 40 to 80 pounds per acre (45 to 90 kg/ha) of P<sub>2</sub>O<sub>5</sub> are recommended. 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 levels of exchangeable soil potassium. Fertilizing to replace potassium removal by the harvested crop is appropriate to maintain soil fertility.

Perennial artichokes require moderate amounts of nitrogen. For maximum yields in most circumstances, growers apply 100 to 200 pounds per acre (112 to 224 kg/ha) of nitrogen. For annual artichokes, fall application of nitrogen is not recommended due to the risk of NO<sub>3</sub>-N leaching beyond the root zone in the winter rains. Small quantities of nitrogen, 20 to 30 pounds per acre (22 to 34 kg/ha), applied preplant are sufficient to provide young transplants sufficient nitrogen for the first month of growth. The need for nitrogen by the crop increases as the crop matures. For instance, early in the season, 5 pounds of nitrogen per week per acre (6 kg/ha) would be sufficient. As plant size increases, 10 pounds of nitrogen per week per acre (12 kg/ha) may be needed. In most field conditions a seasonal fertigation total of 120 to 150 pounds of nitrogen per acre (144 to 180 kg/ha) should be adequate, assuming efficient drip irrigation management. Annual artichokes 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 crops. This nitrogen can be measured by the pre-sidedress 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.

The plant growth regulator gibberellic acid (GA3 or GA4+7), when applied properly, can increase the earliness and uniformity of artichoke bud develop-

ment. It is mostly applied to perennial artichokes to stimulate earliness to meet market demand. One or two applications are applied in July or August. For perennial production, gibberellic acid treatments are sprayed on the field 6 weeks before the expected first harvest at a rate of 10 grams of active ingredient per 100 gallons of water per acre (936 l/ha).

## INTEGRATED PEST MANAGEMENT

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

### Weed Management

Growers use a combination of cultural practices, herbicides, and hand weeding to control weeds. Perennial artichokes are often planted on a grid system that allows mechanical cultivation in two directions following planting, reducing hand weeding to the area around the individual artichoke plants when the plants are small. However, due to the increased plant populations used in perennial artichokes, cross-cultivation cannot be used when the plants get larger. Preemergent herbicides are used on both annual and perennial artichokes. Winter weeds in perennial artichokes are controlled by directed applications of postemergent herbicides. Seeded artichokes can be cultivated two to three times before the canopy closes over the beds; hand weeding removes weeds in the seedline. Key weeds on the central coast include buttercup oxalis (*Oxalis pes-caprae*), swinecress (*Coronopus* spp.), chickweed (*Stellaria media*), mustards (*Brassica* spp.), and sowthistle (*Sonchus* spp.). Buttercup oxalis attracts rodents, as the nutlets are a desirable food.

### Insect Identification and Control

The artichoke plume moth (*Platyptilia carduidactyla*) is the most devastating pest of artichokes. The insect lays eggs on the underside of the fuzzy leaves or on the stem below the buds. The larvae tunnel into the buds, stem, and foliage, damaging the bracts and receptacle and distorting and stunting young buds. The insects reproduce throughout the year, particularly where there is continuous artichoke production. Losses of 25 to 50 percent of all harvestable buds are not unusual on the central coast, even with stringent pest management programs. Artichoke plume moth has not been a problem in the desert production areas. Control depends on strict sanitation practices, including removing infested artichokes found by harvesters and immediately incorporating plant debris into the soil after plant cutback. Integrated pest management

techniques combine sanitation, appropriate cultural methods, insect growth regulators (IGR), pheromone mating disruption, biological control agents, and mass trapping with the reduced use of conventional pesticides.

Aphids, including the bean aphid (*Aphis fabae*), green peach aphid (*Myzus persicae*), and artichoke aphid (*Capitophorus elaeagni*), can be a problem at certain times of the year. In addition to affecting growth, the artichoke aphid may cause sooty mold on the buds, resulting in yield loss. Cribate weevil (*Otiorynchus cribricollis*) larvae feed on the roots, while adults feed on the foliage and buds. Caterpillars, including the salt marsh caterpillar (*Estigmene acrea*) and cutworms (*Peridroma saucia* and others), feed on artichoke foliage and buds. Caterpillars are a particular problem in transplanted annual production, where they can destroy the growth point of developing seedlings.

The proba bug (*Proba californica*) emerged recently as a serious pest on the central coast production. Its life cycle and feeding habits are similar to the lygus bug (*Lygus hesperus*). Proba nymphs and adults feed mainly on young leaves that are in the fond stage. While feeding, they inject a toxin into the plant that causes stunting. Their feeding on the stalk of developing buds causes unsightly scars. The developing buds may also become deformed by the phytotoxin.

Serious infestations of two-spotted spider mites (*Tetranychus urticae*) can cause serious loss of plant vigor and yield. Larvae of the chrysanthemum leaf-miner (*Phytomyza syngenesiae*) damage the foliage by mining the leaves.

### Other Pests

Gray garden slug (*Agriolimax reticulatum*) and brown garden snails (*Helix aspersa*) feed on leaves and rasp off the outer surfaces of artichoke buds, blackening the surface and lowering quality.

Field mice (*Microtus* spp.) and gophers (*Thomomys bottae*) cause considerable economic damage in perennial artichoke fields. These rodents feed on the fleshy roots, young shoots, and developing buds of the plants. Trapping and baits are used to control these pests.

### Disease Identification and Management

Powdery mildew (*Leveillula taurica*) and Ramularia leaf spot (*Ramularia cynarae*) can cause serious economic losses in artichokes. The pathogens attack bracts and foliage and can lead to premature leaf senescence and leaf drop. Damaged buds are unmarketable.

Verticillium wilt (*Verticillium dahliae*) causes wilting, chlorosis, and stunting of plants. Diseased plants produce smaller buds, and the plants may collapse in severe infections. All artichoke varieties are sus-

ceptible to Verticillium wilt. Annual artichokes can be rotated with broccoli to help reduce inoculum levels and manage this disease.

Botrytis rot (*Botrytis cinerea*) is common during rainy weather and prolonged periods of moderate temperatures and high humidity. The fungus usually invades tissue damaged by frost, insects, or improper handling. A gray or brown fungal growth develops on the affected plant parts. Millions of spores quickly develop and are spread by the wind. Postharvest control of Botrytis rot requires appropriate handling, removal of infected heads before packing, and proper cooling during storage and shipment. No practical method for controlling Botrytis rot in the field has been developed.

Curly dwarf is a viral disease that severely stunts and eventually kills infected plants. Symptoms include curling leaves, plant dwarfing, and reduced bud production. Buds may become misshapen and remain small. Curly dwarf is insect-transmitted but the specific vector is not known. The virus survives on milkthistle (*Silybum marianum*) and artichoke plants. The only known control measures are to use noninfected planting stock and immediately remove infected plants.

Bacterial crown rot (*Erwinia chrysanthemi*) causes stunting of artichoke plants and wilting during hot weather. In advanced stages, the plants may collapse. The crown and root tissues become soft, rotted, and turn black or brown. The disease is thought to be spread by harvesting tools. The only known control is to use clean propagation material and avoid spreading the disease during harvesting and propagation. So far the disease has been confined to the coastal region.

Black tip is thought to be a physiological disorder that usually damages only the exposed bracts of small axillary buds. The tips of the affected bracts turn dark brown or almost black, dry, and leathery. Although the edible portion of the bud is not affected, the bud is rendered unmarketable. In annual seeded production, black tip appears most frequently during sunny, warm, windy conditions that increase the growth rate and put plants under moisture stress. The exact cause of the disorder is not known.

### HARVESTING AND HANDLING

Perennial artichokes are harvested year-round, but the highest volume of production occurs between March and May. Seeded artichokes also produce year-round. Winter production occurs in the desert, and production at other times of the year occurs on the coast and in the Central Valley. The highest yields are from fields slated for fall, winter, and spring production.

Artichokes are generally hand-harvested once or twice a week, depending on the weather. During

cold winter weather, perennial fields may go 2 weeks or more between harvests. Perennial artichokes are commonly harvested thirty or more times during the season. Annual artichokes have a shorter, more concentrated production period that reduces harvesting costs.

Artichokes should be harvested when the buds have achieved maximum size, but before the bracts begin to spread open or the internal pappas (fibrous central portion of the bud) grows up above the top edges of the cup-shaped receptacle. The terminal or primary bud is harvested first and is the largest in size. Secondary and tertiary buds are harvested as they reach maximum size. The bracts of some seeded artichoke varieties do not spread open with increasing maturity as readily as do those of the perennial Green Globe. This makes it more difficult to know when to harvest a particular bud. Subtle differences in the color and appearance of the buds as they mature are the only outward clues as to when to harvest. Buds of these seeded varieties do not increase in size if left on the plant past their optimal harvest time. Overmature buds have an internal pappas, turn purple inside, become bitter and woody, and have less fleshy tissue that is edible. Cutting a few buds in half, from the stem to the tip of the bud, to observe the level of maturity in relation to the bud's external color and appearance can help a grower decide when to harvest.

Artichokes are cut by hand with 3 to 4 inches (7.5 to 10 cm) of stem remaining with the bud. Crews select and cut harvestable buds as they walk down the rows. Harvested buds are placed in cloth artichoke bags that are held open by a metal backpack frame. Artichokes are packed on mobile packing frames that move through the field with the crew. Some artichokes are placed in bins for inclusion in value-added packs.

## POSTHARVEST HANDLING

Annual artichokes are inspected in the field for insect or mechanical damage, disease, or cosmetic defects. Unmarketable buds are removed. Marketable buds are sorted by size and quality and packed in fiberboard cartons. Bud size classifications represent the number of buds packed in a standard carton: size 18 buds (18 buds per carton, or "18s") buds are larger than 4.5 inches (11.3 cm) in diameter; 24s are 4.0 to 4.5 inches (10 to 11.3 cm); 36s are 3.5 to 4.0 inches (8.8 to 10 cm); 48s are 3.0 to 3.5 inches (7.5 to 8.8 cm); and 60s are 2.75 to 3.0 inches (6.9 to 7.5 cm). Large or small

loose buds, measuring 1.0 to 2.75 inches (2.5 to 6.9 cm), are jumble-packed, with an average of 100 large buds or 175 small buds per carton. The fresh market prefers 24s and 36s; some retailers prefer 36s and 48s since artichokes are usually priced by the bud rather than by the pound. Field-packed artichokes are usually cooled by forced air. Although yields of 800 or more cartons per acre (1,975 per ha) are considered good, the harvest period and total yield depend on market conditions. Individual cartons must weigh at least 22 pounds (9.9 kg) each.

Most perennial artichokes are field-packed. Marketable buds are graded by size and quality and packed in waxed fiberboard cartons. Bud size classifications are the same as for annual production. Although yields of 600 or more cartons per acre (1,480 per ha) are consistently achieved, the harvest period and total yield depend on market conditions.

Artichokes should be held at or near 33°F (1°C) at 90 to 95 percent relative humidity during storage and shipping to help maintain quality, retard Botrytis rot, and prevent desiccation. Artichokes are shipped to markets in refrigerated trucks.

## MARKETING

California accounts for over 99 percent of commercial artichoke production in the United States. Artichoke prices tend to be lower in March as perennial production increases. From 2003 to 2005 California annually exported 4,393 tons (3,984 metric tons) of artichokes to Canada and 1,741 tons (1,578 metric tons) to Mexico. California artichokes are also exported to Japan and Europe. A limited market has started for fresh, trimmed artichoke hearts, mostly for the upscale restaurant trade. A small proportion of artichokes are also sold through local farmer's markets, community-supported agriculture, and direct to retail marketing avenues.

## COSTS OF PRODUCTION

The cost of artichoke production varies by location, since inputs such as water, land lease, fertilizer, pesticide, etc., depend on weather, soil, and other local factors. Generally, artichoke production is labor-intensive, especially in harvesting and postharvest handling. For more information, see *Sample Cost to Establish and Produce Artichokes, Imperial County, 2004*, at the UC Davis Agriculture and Resource Economics Web site, <http://coststudies.ucdavis.edu/files/artichokes04.pdf>.

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E-mail: [danrcs@ucdavis.edu](mailto:danrcs@ucdavis.edu)

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Publication 7221  
ISBN-13: 978-1-60107-615-1

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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