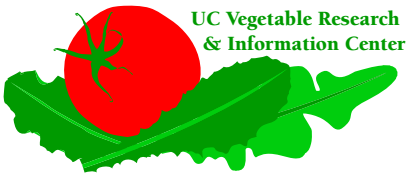

Vegetable
Production Series

ASPARAGUS PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

California has three primary asparagus *(Asparagus officinalis)* production areas: the Sacramento–San Joaquin River Delta (San Joaquin, Sacramento, and Contra Costa Counties), the Central Coast (Monterey and San Benito Counties), and the San Joaquin Valley (Fresno, Kern, Merced, and Kings Counties). However, asparagus is broadly adaptable, and limited acreages of asparagus are grown in various other parts of the state, from the Sacramento Valley in the north to the Imperial Valley in the south. Asparagus is a perennial crop that is normally harvested once per year over an 8- to 12-week period. The main harvest season is in the spring, but some may be cut in the fall (September and October). Asparagus may be harvested from January to early April in the southern desert valleys, from late February through May in the Delta and the San Joaquin Valley, and from March to mid-June on the Central Coast. California produces only green asparagus; white asparagus is no longer produced. Most California-grown asparagus is sold for the fresh market; less than 1% of the crop is processed. The harvested acreage for 2009 was 12,500 acres, a decline of 63% from the acreage harvested in 2004.

ASPARAGUS ACREAGE AND VALUE

Year	Acreage	Average yield (*ton/acre*)	Gross value/acre
2009	12,500	1.60	$4,160
2008	14,500	1.45	$3,625
2007	20,000	1.45	$3,509
2006	22,500	1.15	$2,714

SOURCE: California Agricultural Statistics 2009 (Sacramento: California Department of Food and Agriculture, 2010).

CLIMATIC REQUIREMENTS

Asparagus favors temperate climates. Optimal root and fern (foliage) growth occurs from 65° to 85°F (18° to 29°C). Spear (edible shoot) initiation occurs at soil temperatures above 50°F (10°C); spear elongation is faster at higher air temperatures. Root and fern development are reduced at temperatures below 55°F (13°C) or above 85°F (29°C). High temperatures cause the spear tips to open ("feather") prematurely, reducing overall spear quality.

VARIETIES AND PLANTING TECHNIQUES

Varieties. The principal cultivars grown are UC157 and De Paoli, with limited acreages of other varieties.

Planting. Although asparagus can be established by direct seeding or transplanting of greenhouse-grown seedlings, current plantings are established with field-grown 1-year-old crowns. October through March is the best time for planting transplants or crowns. Crowns are normally placed in the bottom of a furrow and soil is mounded over the plants as they develop to fill in and form a raised bed. Bed width varies from 40 to 72 inches (100 to 180 cm), depending on grower preference. In-row spacing for crowns is usually 6 to 12 inches (15 to 30 cm). In the desert, there are normally two rows per 60-inch (1.5-m) bed, giving a population of 17,000 to 20,000 plants per acre (42,500 to 50,000 plants/ha). Plant populations using one row per bed vary from 9,000 to 13,000 plants per acre (22,500 to 32,500 plants/ha).

SOILS

Careful attention should be given to field selection because asparagus will occupy the land for 8 to 10 years. Fields should be uniform in soil type to

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facilitate the timing of irrigation that is appropriate for the whole field. Locations known to have problems with bermudagrass *(Cynodon dactylon)*, field bindweed *(Convolvulus arvensis)*, johnsongrass *(Sorghum halepense)*, or nutsedge (*Cyperus* spp.) are poor choices for asparagus production because these perennial weeds are difficult to control in established asparagus. The ideal pH for asparagus is 6.5 to 7.5. Acidic conditions (less than pH 6.5) can lead to reduced growth and yield. Corrective annual applications of lime may be necessary to elevate pH levels. Asparagus has a high tolerance for salt; a saturated soil extract can have an electrical conductivity (EC) as high as 6 dS/m with no impact on yield.

In the principal asparagus production area of California, the Sacramento–San Joaquin River Delta, most of the soils are high in organic matter and have a high water table. Care must be exercised in applying water to these soils to prevent the development of soilborne diseases. Provisions are made for drains and pumps to remove water that accumulates from irrigation and rainfall. In areas adjacent to the San Joaquin Delta and along the Central Coast a wide variety of sedimentary soils (ranging from sandy loam to some clay loams) are used for asparagus production. Shallow soils or those with a perched water table should be avoided, as these conditions lead to a short stand life due to unhealthy or diseased roots.

IRRIGATION

Water is required to replace moisture lost by evapotranspiration and to leach salts that have accumulated in the soil. The volume of applied water varies greatly among production regions. In the Imperial valley, 48 to 60 inches of water (14,640 to 18,300 mm) is applied; in the San Joaquin Valley and Central Coast areas 18 to 30 inches (5, 490 to 9,150 mm) is applied to mature plantings. In the San Joaquin Delta, a significant portion of the water needs of asparagus are supplied from a shallow water table.

As new plantings emerge in the spring, frequent irrigations may be needed to maximize fern growth. As fern growth increases in established plantings after harvest, applied water is increased to match the water extraction of the crop. Water applications are cut back in late summer and early fall to curtail new fern growth as the crop transitions into winter dormancy. Although asparagus is considered to be drought tolerant, if water is cut back too severely, spear yield and size can decline during the subsequent harvest season. After removal of ferns in the fall, crop water requirements are low. Formerly, in the San Joaquin Delta, many of the fields high in organic matter were flooded for a period of 30 days during the winter, when the crop was dormant, to refill the soil profile and leach accumulated salts. Oversaturating the soil during cool conditions can exacerbate root diseases. More commonly today, a single heavy irrigation is done in late December or early January. Other production fields on sedimentary soils in the Delta and on the Central Coast rely on winter rainfall or irrigation before harvest for early-season moisture.

In the desert region, fields are usually irrigated to moisten the soil before harvest and periodically irrigated to maintain moisture near the soil surface during harvest. Asparagus spear size and yields are higher if soil moisture is maintained near field capacity during the harvest period. Irrigations are made to alternate furrows to maintain a dry furrow for foot traffic during harvest. Because of the long harvest period on the Central Coast, periodic irrigations are also required to maintain moisture near the soil surface. Overhead sprinklers are also used during the harvest period because light applications can be made to allow harvest crews and equipment access into fields within a few days after irrigating.

Asparagus is typically furrow irrigated in all growing regions of California. The interval between irrigations during the summer is from 10 to 15 days (longer in the Delta, where some of the water may be supplied from a shallow water table). Approximately 3 to 6 inches (915 to 1,800 mm) of water is applied with each furrow irrigation. Overhead sprinklers may also used to irrigate asparagus during the summer.

The use of subsurface drip irrigation in asparagus is increasing in California. Drip permits growers to irrigate during the harvest period without impeding field access by harvest crews and equipment. One line of drip tape per bed is placed 3 to 6 inches (7 to 15 cm) below the depth of the crown. Tape with a wall thickness greater than 10 mil is recommended to resist puncture from soil insects. Irrigation needs for drip irrigation can be determined by weather-based reference evapotranspiration (ET_o) estimates and crop growth stage; frequency of irrigation can vary from once per week early in the season to 2 to 3 times per week during periods of peak water demand.

A combination of soil moisture monitoring and weather-based irrigation scheduling can be used to determine the water needs of asparagus. Water use is highest when ferns reach maximum size. Irrigations should be scheduled when soil moisture tensions are above 50 centibars (50 kPa). Water extraction of asparagus can be estimated using reference evapotranspiration data adjusted with a crop coefficient, which is closely related to the percentage of ground covered by the canopy.

At a maximum canopy cover of 85%, the crop coefficient is nearly 1.0. The California Irrigation Management Information System (CIMIS, www.cimis.water.ca.gov) coordinated by the Department of Water Resources provides daily estimates of reference evapotranspiration for most production regions of California.

FERTILIZATION

Fertilization practices for asparagus production depend on the field conditions and the age of the planting. In preparing a new field for planting the soil test levels of phosphorus (P) and potassium (K) should guide fertilization rates. Fields with Olsen (bicarbonate-extractable) soil phosphorus greater than 15 ppm have modest preplant phosphorus requirements of less than 100 pounds per acre (112 kg/ha) of P_2O_5, while fields with less than 10 ppm soil phosphorus may require 200 pounds per acre (224 kg/ha) of P_2O_5 or more. Fields with exchangeable soil potassium greater than 150 ppm potassium require no preplant potassium, while fields with less than 100 ppm may benefit from application of up to 200 pounds per acre (224 kg/ha) of K_2O. Once an asparagus planting is established and producing, the annual phosphorus and potassium removal by the spears is modest; annual maintenance applications in the range of 50 pounds per acre (56 kg/ha) of P_2O_5 and 50 to 75 pounds per acre (56 to 84 kg/ha) of K_2O should be adequate to maintain soil fertility. In the first 2 to 3 years after establishment, annual nitrogen (N) rates of up to 200 pounds acre (224 kg/ha) may be used to build up the nitrogen stored in the crowns. On established plantings that are efficiently irrigated, annual rates of 100 to 150 pounds per acre (112 to 168 kg/ha) of nitrogen should be sufficient. Nitrogen application is most efficient during active fern growth.

INTEGRATED PEST MANAGEMENT

Detailed information about IPM for asparagus is available at the UC IPM World Wide Web site, http://www.ipm.ucdavis.edu (see *UC IPM Pest Management Guidelines for Asparagus*, ANR Communication Services Publication 3435, 2009). Herbicides, insecticides, fungicides, and preplant fumigants should always be used in compliance with label instructions.

Weed management. Weeds can become a serious and costly problem in both newly planted and established asparagus. Selection of a relatively weed-free planting site is essential. Prior to planting, irrigation to germinate weeds followed by cultivation or application of a postemergence herbicide, or both, can aid in reducing weed competition. On established asparagus, a preemergence herbicide should be applied prior to the start of the harvest season; some preemergence herbicides can be applied during the cutting season. Water in the form of rainfall or sprinkler irrigation is needed to activate the herbicide. During the cutting season, spot treatments with an herbicide may be necessary to control weeds such as bermudagrass (*Cynodon* spp.). A good time to control weeds mechanically, and to apply preemergence herbicides for specific broadleaf and grass weeds, is after the harvest season, before the field is allowed to fern. Winter weed control can be accomplished mechanically or with preemergence herbicides.

Insect identification and control. Western yellowstriped armyworm *(Spodoptera praefica)*, beet armyworm *(Spodoptera exigua)*, bean thrips *(Caliothrips faciatus)*, western flower thrips *(Frankliniella occidentalis)*, onion thrips *(Thrips tabaci)*, cutworms *(Peridroma saucia* and *Euxoa messoria)* and asparagus beetle *(Crioceris asparagi)* have been occasional pests requiring insecticide treatments. When found in maturing ferns, the European asparagus aphid *(Brachycorynella asparagi)* is the most serious pest requiring insecticide treatments for control. Asparagus miner *(Ophiomyia simplex)* may need to be controlled periodically in the Imperial Valley. Garden symphylan *(Scutigerella immaculata)*, a white arthropod closely related to insects, may cause damage to asparagus roots and crowns, leading to some crop stand loss if found in large numbers. Garden symphylans typically are most severe in soils with high levels of organic matter. A preplant application of a fumigant or a soil-active insecticide can control this pest. Effective controls for postplant management have not been developed.

Disease identification and management. Fusarium crown and root rot *(Fusarium oxysporum*, f. sp. *asparagi, Fusarium verticilliodes,* and *F. proliferatum)* is the most serious disease affecting asparagus production worldwide. Fusarium causes a slow decay of the crown and reduces spear size and number, ultimately leading to lower yields. The problem increases with the age of the crop stand. Severity of the disease can be reduced by selecting vigorous-growing varieties (hybrids), planting clean seed and one-year-old crowns grown in noninfested soil, and practicing good irrigation management. Replanting asparagus in the same field should be avoided for at least a 10-year period. Fusarium has a drastic effect on younger asparagus plantings in infested soil. Excessive harvesting of mature asparagus weakens the crowns and increases stand decline caused by Fusarium crown and root rot.

Asparagus crown and spear rot (*Phytophthora megasperma* var. *sojae* and other *Phytophthora* spp.) is a soilborne fungal disease that is a particular problem in soils that are saturated due to poor drainage, heavy rainfall, or excessive irrigation. Crown and spear rot and can occur if corrective and preventive measures

are not employed, resulting in stand loss and reduced production. Chemical and cultural controls can be employed against this disease.

Asparagus rust *(Puccinia asparagi*), a fungal disease affecting the asparagus fern, may require chemical control during some years. Good irrigation management, wide row spacings, orientation of planted rows with the prevailing wind, and thorough removal and destruction of infected fern may help reduce the incidence or severity of asparagus rust.

Asparagus purple spot *(Stemphylium vesicarium)* may occur during cool, wet weather at harvest. It causes oval-shaped purple spots on the spears. The spots elongate and produce grayish white, slightly sunken centers within the lesion. The primary source of inoculum for purple spot is fern debris from the previous season's crop. Good sanitation, including fern chopping and soil incorporation of the debris, minimizes occurrence of the disease under California's climatic conditions.

Asparagus viruses I and II (AVI and AVII) are symptomless, latent diseases that can decrease production and reduce plant vigor over time, particularly when both viruses are present in a field. AVI is insectborne and moves through a field as insects move pollen from an infected male plant to female plants. AVII is the more serious of the two because it is seedborne and has been spread to some degree into most asparagus production areas in California. The best control measure is to plant fields with certified virus-free seed or transplants cloned from healthy mother plants. AVII is also spread by sap on cutting knives during harvest. It has been shown that AVII predisposes plants to further damage from Fusarium crown and root rot.

HARVESTING AND HANDLING

Mature ferns are either chopped, often as part of the green trash hauled from the field, or windrowed with a swather. After drying, chopped ferns are incorporated into the bed with a rotary power tiller. Fern chopping occurs from late November to early December in the desert and Delta growing areas. Following chopping, the planted beds are reworked to loosen the surface soil, reshaped, and fertilized.

Emerging spears are hand-cut. Early in the season, fields are harvested every 2 or 3 days, but during warm weather fields are cut daily. Spears are cut at an angle just below the soil surface with an asparagus knife. Spindly or otherwise deformed spears are cut and discarded to allow for growth of marketable spears. Cut spears must be approximately 10 inches (25 cm) long to allow for a trim to 9 inches (22.5 cm) during packing. Harvested spears are placed on the beds in bunches, gathered, and placed in field boxes or cart-carrying tractors. They are then taken out of the field and hauled to sheds for grading, packing, trimming, and cooling.

Defects and loss of production at harvest can occur for various reasons. Drying wind and blowing sand can dry out the cells on the side of the spear facing the wind causing the spear growth to bend into the wind. Spears can grow at a rate of 3 to 6 inches (7.5 to 15 cm) per day, depending on the temperature (faster when warmer). Windborne soil debris may also pit the emerging spears, making them unmarketable. Trampling or inadvertent cutting of emerging spears and high temperatures cause misshapen spears. Cutting spears too far below the ground may cause the additional loss of spears that never reach the bed surface. High temperatures can cause small-diameter spears, tapered spears, loose heads, and premature breaking of the bracts, especially in small spears. This premature breaking is commonly referred to as feathering. Harvesting a bed for too long during the season may also cause spear feathering due to low carbohydrate levels in the crowns. Thrips and mite feeding can cause significant reduction in the cosmetic appearance of spears.

Freezing temperatures during spear emergence can cause frosting, a discoloration of green spears. Frosted spears may still be marketable, albeit at a reduced value, but most often they are discarded. If spears are cut while frozen, damage is usually severe and the product is not marketable. Ice formation may be difficult to see because the ice is clear, a condition known as black ice. A field with black ice will be a darker green than normal.

Excess harvesting leads to a decline in production and a proliferation of small spears. Fields in their second year of production after transplanting (crowns or seedlings) may be harvested, yielding 25 to 50 28-lb-cartons per acre (62 to 124 per ha), but the harvesting period should be limited to 3 to 4 weeks and should be done only in the most vigorous plantings. During the third year, 50 to 80 cartons per acre (62 to 198 per ha) may be harvested. A full cutting season (60 to 75 days) may begin the fourth year after planting. Depending on location, field history, irrigation, fertilization, length of cutting season, and so on, full harvest seasons can result in yields of 100 to 175 cartons, or 2,800 to 5,000 pounds per acre (3,136 to 5,600 kg/ha).

Asparagus fields should produce good yields for 8 to 10 years. Asparagus is capable of a much longer production life, but it is usually limited in later years by weed infestations and decline due to disease and overcutting of the beds.

POSTHARVEST HANDLING

Asparagus is packed in various sizes of containers (wood, waxed fiberboard, and composite corrugated plastic) including 30-pound loose, 28 bunches per crate (net weight 28 lb), and 11 bunches per crate (net weight 11 lb). Cartons usually are pyramid shaped for vertical placement of bunched and banded spears. A number of specialty packs and 15-pound horizontal packs of spear tips have become common, especially for food service. Standards for spear sizes are as follows.

Size	Diameter (in.)
Colossal	$^{16}/_{16}$
Jumbo	$^{13}/_{16}$
Extra Large	$^{10}/_{16}$
Large	$^{7}/_{16}$
Standard	$^{5}/_{16}$
Small	$^{3}/_{16}$

Diameter is measured at the widest point of the spear. Large, Standard, and Small grades are typically shipped in 11- and 28-pound cartons. Another commonly used container holds six 2.25-pound bunches (net weight 13.5 lb), often used for international shipment. Sizes for this pack include Colossal (no more than 14 spears per bunch), Jumbo (15 to 20 spears), Extra Large (18 to 24 spears), Large (21 to 28 spears), and Standard (29 to 42 spears).

Some of the product is packed in 30-pound wooden crates, chiefly for Japanese export. There are also 27-pound cartons (twelve 2.25-lb bunches) for domestic and export markets, 18-pound cartons of asparagus tips (5½ to 7 inches in length) for domestic use, and 15-pound cartons packed loose for export, primarily to Europe.

Asparagus is an extremely perishable product that must be cooled quickly after harvest. Delays to cooling as short as 4 hours may result in noticeable toughening. Extended delays in cooling and warm temperatures in transportation may result in bacterial soft rot on the tips. Local packing sheds hydrocool spears to remove the field heat after packing. To remove the field heat from the spears, disinfectant-treated water is drenched over the packed cartons, which are designed with large vents or slat openings for ample water contact. This drench is done for approximately 15 minutes at approximately 34° to 37°F (1.1° to 2.8°C); water disinfectants used include chlorine, hypochlorite, chlorine dioxide, and peroxyacetic acid. To maximize shelf life, asparagus should be stored at 36° to 40°F (2.2° to 4.4°C) with 90 to 95% relative humidity. Typically, asparagus is shipped in containers with an absorbent pad saturated with the hydrocooling water to reduce moisture loss and maintain high relative humidity.

At high temperatures, asparagus spears lose natural sugar, flavor, and Vitamin C, and they become tough and start to decay. If rapidly cooled and held at 36°F (2.2°C), asparagus may be kept for about 3 weeks. Asparagus is chilling sensitive and take on a dull, gray appearance after about 10 days at 32°F (0°C). Severe chilling injury during long international shipments appears as wilted and ribbed spears with dark streaks, especially near the tips.

Desiccation can occur rapidly if the butt ends of the asparagus spears are not placed on wet pads or shipped in special deep-well trays that retain water. However, excess water and warm temperatures often result in bacterial soft rot at the butt since spears continue to elongate after harvest. Storing asparagus in unventilated containers or extended exposure to external sources of ethylene may result in noticeable spear toughening. Elevated carbon dioxide, up to 10%, is beneficial in preventing decay and slowing toughening; benefits are generally realized with moderate lengths of storage or transport.

MARKETING

California is the leading asparagus-producing state in the United States, followed by Michigan and Washington. California produces asparagus for 7 months of the year, with the heaviest production from March to May. About 17% of California asparagus production is exported outside the United States, primarily to Canada, Switzerland, and Japan.

FOR FURTHER INFORMATION

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