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Broccoli Production in California

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Broccoli was introduced into the United States by Italian immigrants in the early twentieth century and since that time has become an increasingly popular vegetable.

Production areas and seasons

Broccoli is produced during the cool season in California. There are three main areas of commercial production in the state. Sixty percent of total California production (table 1) is along the Central Coast (Monterey, San Benito, Santa Clara, and Santa Cruz counties); 22 percent is produced on the South Coast (Ventura, Santa Barbara, and San Luis Obispo counties); and 18 percent is produced in the southern desert valleys (Imperial and Riverside counties). Broccoli is also produced in the Central Valley (Fresno, Stanislaus, and Tulare counties). Broccoli is grown year-round on the Central Coast and in South Coast valleys, but with reduced planting and harvest in December. In the southern desert valleys, broccoli is planted from early September through early December for harvest in the winter and early spring.

Climatic requirements

Broccoli (*Brassica oleracea* L. var. *Italica* Plenck) is a hardy, cool-season vegetable in the Brassicaceae family. This species also includes Brussels sprouts, cabbage, cauliflower, collard greens, gai lan, kale, and kohlrabi. Broccoli seed will germinate and grow from 40 to 95°F (4–35°C), but optimum growth occurs when air temperatures average from 60 to 65°F (16–18°C). However, heat-tolerant varieties are now available that can produce marketable broccoli heads in areas where temperatures may spike above the optimal range.

TABLE 1. Broccoli acreage, yield, and value

Year	Acreage	Average yield (tons/acre)	Gross value/acre
2022	85,000	6.3	$8,158
2021	95,000	6.5	$6,646
2020	90,000	8.0	$8,690
2019	100,000	8.0	$7,888
2018	104,000	7.8	$6,603
2017	120,000	8.0	$7,152

Source: California Department of Food and Agriculture. 2022. California agricultural statistics review 2021–2022. Sacramento: California Department of Food and Agriculture.

Broccoli produces one compact flower head on a tall, green, branching stalk (fig. 1). The flower head is from 3 to 8 inches (7.5–20 cm) in diameter and plants average 12 to 24 inches (30–60 cm) tall. A desirable broccoli head has a tight dome shape with small uniform beads (flower buds) which are blue-green to green in color. Depending on the variety, the position of the head is either just above the leaves or several inches above the upper canopy. Broccoli varieties in which heads are elevated above the canopy facilitate mechanical harvest.

Cultivars

All commercial broccoli produced in California are hybrids of the Italian green type, also called green-sprouting broccoli, or calabrese. Current broccoli cultivars typically take from 70 to 140 days to grow from planting to marketable maturity, depending on the season of production. The varieties differ in color and size of plant, size of head and florets, and extent to which side shoots (small lateral heads) develop below the terminal head. Proper cultivar selection for each planting period and area is critical to obtaining high yields and desirable head quality.

Although broccoli grows best at cool temperatures, substantial planting occurs when temperatures are high in the hot interior and desert valleys of California. Typically, the planting date is selected so that the crop matures as the weather cools to optimum temperatures for crop development. These areas have cooler winters than the coast and colder-than-optimal temperatures may occasionally occur. Seed company breeders and distributors conduct extensive trials in commercial fields to help determine appropriate varieties for different planting slots.

Figure 1. Broccoli head ready for harvest.

In the Central Coast production area, commonly planted varieties include Centennial, Diamante, Emerald Crown, Grandslam, Heritage, Ironman, Kariba, Legacy, Marathon, Millennium, Patriot, Patron, Secretariat, and SV 1822. In the South Coast area, commonly planted varieties are Avenger, Diamante, Endurance, Green Magic, Heritage, Imperial and Patron. In the southern desert, Castle Dome, Destiny, Dynasty, Emerald Crown, Emerald Star, Expo, Green Magic, Karibe, Liberty, Millennium, Sarasota, SVR 1764, and Tahoe are commonly planted.

Planting

Broccoli can be direct seeded (fig. 2) or transplanted. In most areas of the state, broccoli is direct seeded, with the exception of the South Coast, where fields are predominantly transplanted. However, due to economic pressures and new developments in transplant technology, the use of transplants is increasing (fig. 3). Broccoli, whether direct seeded or transplanted, is typically planted in double rows on beds 38 to 42 inches (95–105 cm) wide or four rows on beds 76 to 84 inches (190–210 cm) wide. Within-row spacing varies from 4.5 to 6 inches (11.5–15 cm) and spacing between seed lines is 12 to 14 inches (30–35 cm). Broccoli is occasionally planted in single

Figure 2. Seedlings from direct-seeded broccoli emerging in a double-row 40–inch wide bed.

Figure 3. Broccoli seedling established by a PlantTape transplanter.

rows on 30-inch (75-cm) beds with plant spacing at 5 to 6 inches (12.5–15 cm). A typical broccoli planting has approximately 52,000 to 70,000 plants per acre (133,000–178,000 per hectare [ha]) (fig. 4). When direct seeded, broccoli is planted with seeding rates of 1 to 1.5 pounds of seed per acre (1.1–1.7 kg/ha), depending on spacing and seed size. Seeding depth ranges from 0.125 to 0.75 inch (3–19 mm), with 0.5 inches (12 mm) being most common.

Soils conditions

Broccoli is grown on a range of soil textures; however, the soil needs to be well-drained for broccoli to grow vigorously and to yield well. Fields with light soils are often used for winter/spring crops to minimize potential harvest delays caused by rain. Broccoli is moderately salt tolerant, having greater salt tolerance than other vegetables including melons, corn, lettuce, peppers, onions, and carrots. Yield reductions have been measured at soil salinity levels above 2.8 decisiemens (dS)/meter (m) (electrical conductivity of a saturated paste extract [ECe] in millimhos [mmho]/cm at 25°C). Yield losses are approximately 9 percent for each increase in soil salinity of 1 dS/m above this threshold.

Irrigation

Broccoli requires adequate soil moisture for maximum yield and quality, especially during flower-head formation. Overwatering can cause quality defects such as loose heads or hollow stems and can promote root diseases. Broccoli is irrigated with sprinkler, drip, or furrow irrigation. It is common for growers to use sprinkler irrigation for the first 3 to 4 weeks to allow direct-seeded crops to establish, or transplants to set, then switch to drip or furrow irrigation for the remainder of the crop cycle. Sprinkler and surface drip are the most common irrigation practices on the Central and South Coasts. In the low desert region, sprinkler irrigation is typically used for stand establishment, after which the crop is irrigated by furrow. The amount and frequency of irrigation depends on soil type, weather conditions, crop development stage, irrigation method, and salinity of the soil and water. Growers typically pre-irrigate fields with 1 to 2 inches (3–5 cm) of water to moisten soil for bed preparation and shaping. An additional 3 to 4 inches (8–13 cm) of water is applied for germination of seed or transplant establishment during the first 3 weeks of the crop. Soil moisture monitoring in the plant row is highly recommended to avoid overirrigating during this early phase of the crop. Post-establishment water applied on the Central and South Coast during the summer ranges from 9 to 14 inches (23–36 cm), depending on the soil type, irrigation method, and weather conditions. Depending on the rainfall pattern, broccoli grown during the winter on the Central Coast usually receives less than 6 inches (15 cm) of irrigation water after establishment. Post-establishment irrigation for broccoli grown in the low desert region may range from 15 to 24 inches (38–61 cm), depending on the irrigation efficiency and planting date. In the low desert, crops planted in the fall will have lower water requirements than crops planted during the late summer due to cooler conditions and less solar radiation.

Figure 4. View of a typical stand of broccoli (just prior to heading).

The combination of soil moisture monitoring and weather-based irrigation scheduling can be used to determine water needs of broccoli. During the spring and summer, water use is highest during the last month before harvest, when the canopy has closed and vegetative growth is rapid. Soil moisture tensions are typically targeted for less than 30 to 45 centibars (30–45 kPa) during this period. Water extraction of broccoli can be estimated using reference evapotranspiration data adjusted with a crop coefficient (Kc) that is closely related to the percentage of ground covered by the canopy (C):

$$Kc = 0.0063 + (1.75 \times C - 0.0065 \times C^2) \div 100$$

At a maximum canopy cover of 95 percent, the crop coefficient is nearly 1.1. Crops established with sprinklers should use a crop coefficient between 0.3 and 0.7, depending on the frequency of irrigation, until the canopy is greater than 30 percent ground cover. The California Irrigation Management Information System (CIMIS), administered by the California Department of Water Resources, provides daily estimates of reference evapotranspiration for most production regions of California. Online decision support software such as CropManage can be used to estimate crop water requirements based on evapotranspiration data and can provide guidance on scheduling of irrigations.

Fertilization

Water quality regulations issued by Regional Water Quality Control Boards are designed to reduce leaching losses of nitrate nitrogen (NO_3-N) to safeguard groundwater, which is the source of drinking water for many municipalities and rural households. As a result, there is increasing pressure for growers to carefully manage nitrogen inputs to comply with regulations.

Nitrogen management

Broccoli have the curious characteristic of turning purple when they are nitrogen-deficient (fig. 5). Broccoli requires large quantities of nitrogen to successfully produce a high-quality crop. Sufficient soil nitrogen is needed to build a large and vigorous plant that grows a vigorous root system during the first half of the crop cycle. Despite the crop taking up 250 to 350 pounds of nitrogen per acre (280–392 kg/ha), broccoli on the Central Coast is commonly fertilized with 160 to 220 pounds of nitrogen per acre (179–246 kg/ha). Therefore, broccoli commonly scavenges 100 to 150 pounds of nitrogen per acre (112–168 kg/ha) from the soil profile (Smith et al. 2016). Given the moderately long crop cycle of broccoli, it is capable of growing roots down to 3 feet (91 cm) deep (fig. 6). On the Central Coast, where multiple crop rotations in a year are possible, there is often enough residual soil nitrate deep in the soil profile that broccoli can supply a large portion of nitrogen demand by scavenging it from deep in the soil profile.

A typical fertilizer practice is to apply a starter fertilizer of 20 to 30 pounds of nitrogen per acre (22–34 kg/ha). Postplanting fertilizer application rates can be guided by the pre-sidedress soil nitrate testing. Soil nitrate levels greater than 20 parts per million in the top 12 inches (30 cm) are adequate for crop growth up to 2 weeks; on soils with this level of nitrate, a fertilizer application can be skipped or reduced. If nitrate tests indicate that fertilizer is needed, 50 to 75 pounds of nitrogen per acre (56–84 kg/ha) should be applied. By midway through the crop cycle, broccoli often thoroughly depletes much of the soil nitrate in the top foot of soil and measurements of residual soil nitrate in the second foot can help guide further fertilizer applications. In soils with low levels of residual soil nitrate, broccoli may be fertilized two to three times to supply sufficient nitrogen. Nitrate nitrogen in the irrigation water can also be a source of nitrogen for crop growth. The amount of nitrogen supplied by irrigation water can be calculated by the following formula:

$$NO_3\text{-N} \times 0.23 = \text{lb N/acre-inch of applied water.}$$

Levels of NO3-N in irrigation water greater than 20 parts per million can provide sizeable quantities of nitrogen to crops.

Only 25 to 30 percent of the nitrogen in the crop biomass is removed in the harvested broccoli heads. The remaining broccoli residue contains 190 to 260 pounds of nitrogen per acre (213–188 kg/ha). This residue contains 3 to 4 percent nitrogen, which results in up to 60 percent of the nitrogen in the residue mineralizing in 4 to 6 weeks. This source of nitrogen can provide a significant portion of the nitrogen needs for subsequent crops if it is not leached by excessive irrigation or rainfall before crop uptake.

Phosphorus, potassium, and zinc

Phosphorus fertilization should be applied based on the soil test results for bicarbonate-extractable phosphorus. Levels above 50 parts per million are adequate for broccoli growth; for soils below this level, especially in the winter, preplant applications of 40 to 80 pounds per acre (45–90 kg/ha) of phosphate are recommended (Hartz 2020). The need for potassium can also be determined from soil tests; soils with greater than 150 parts per million of ammonium acetate–exchangeable potassium have enough to supply the crop. Potassium fertilization presents no environmental risk, and

Figure 5. Broccoli plants turning purple due to low levels of nitrogen in the soil.

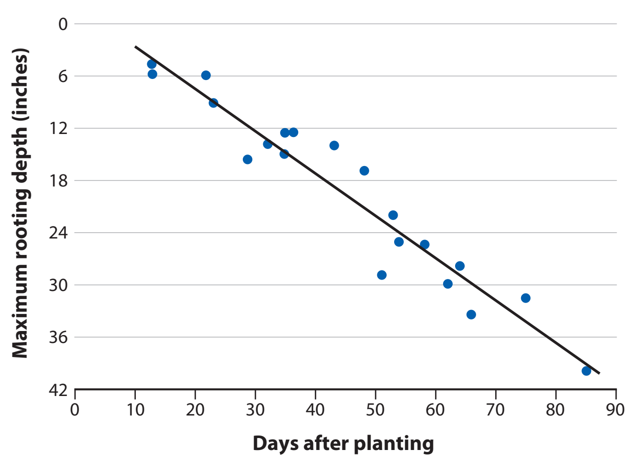

Figure 6. Progression of broccoli rooting depth over the crop cycle. *Source:* Smith et al. 2016.

growers may apply potassium even in fields with high exchangeable soil potassium to replace what is removed in the crop. Potassium application rates of 100 to 140 pounds per acre (112–157 kg/ha) is appropriate for maintaining soil fertility. Zinc fertilization is recommended if 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

Integrated pest management information is continually being developed for weed, insect, and disease problems in California broccoli production. Cultural control methods such as mechanical cultivation, field sanitation, good drainage, and irrigation management to avoid excessively wet soils are important components of integrated pest management that help minimize crop protection needs. A good balance of synthetic and biological pesticides helps maintain pest control efficacy, minimize the risk of resistance development, and ensure environmental safety. Pesticides should always be used in compliance with label instructions. For more detailed information about broccoli pest identification, biology, and management, consult the UC Integrated Pest Management Guidelines.

Weed management

Regional differences in weed problems are significant. In the coastal areas, winter and spring weeds are favored by cool, moist conditions and they are the predominant weeds most of the year. In the Imperial and San Joaquin Valleys, early crops compete with weeds that germinate in warm to hot conditions from midsummer to late fall. Later fall and winter plantings compete with annual winter weeds. During the cool season, common problem weeds in all areas include sowthistle (*Sonchus oleraceus*), burning nettle (*Urtica urens*), chickweed (*Stellaria media*), common groundsel (*Senecio vulgaris*), little mallow (*Malva parviflora*), London rocket (*Sisymbrium irio*), prickly lettuce (*Lactuca serriola*), and shepherd's purse (*Capsella bursa-pastoris*). During the warm season, they include common lambsquarters (*Chenopodium album*), nettleleaf goosefoot (*Chenopodium murale*), nightshades (*Solanum* spp.), pigweeds (*Amaranthus* spp.), purslane (Portulaca oleracea), and nutsedge (*Cyperus* spp.).

Preplant irrigation to stimulate weed emergence followed by shallow tillage is a common practice to reduce weed pressure in both organic and conventional production. Most conventionally produced fields are treated with pre-emergence herbicides at seeding, which reduces early-season weed pressure. Three to 4 weeks after planting, there are three operations can be used to further remove weeds: (1) standard cultivation to mechanically remove weeds from the majority of the bed, except for a band around each seedline 3 to 4 inches in width; (2) automated weeding to selectively remove weeds from the uncultivated seedline (fig. 7); and (3) application of a postemergence broadleaf herbicide or foliar application of liquid ammonium nitrate to burn back weeds (the waxy cuticle of the broccoli plant protects it from the post-emergent herbicide and fertilizer application) (fig. 8). Postemergence grass herbicides registered on broccoli are also used in areas with problems with these weeds. Hand hoeing is the final weed control operation but can be extremely expensive if weeds are not adequately controlled or suppressed by the practices just described. It is carried out as needed before the canopy gets too large for the crew to enter the field without breaking broccoli plants.

Insect identification and management

A variety of invertebrate pests damage broccoli roots and seedlings. Seedcorn maggots (*Delia platura*) feed on germinating broccoli seeds and roots. Cabbage maggots (*Delia radicum*) also feed on roots, including the feeder

Figure 7. Automated weeder with split blades that can weed in the seedline in between crop plants.

Figure 8. A dead shepherd's purse plant killed by an over-the-top application of liquid nitrogen fertilizer that did not damage the broccoli plant.

roots, and bore into the taproot; they can cause significant loss of plant stand and vigor (fig. 9). Wireworms (*Elateridae* sp.) and garden symphyllans (*Scutigerella immaculata*) feed on the roots of developing plants, stunting growth and causing stand loss. Flea beetles (*Phyllotreta* sp., *Epitrix cucumeris*, and *Systena blanda*) and cutworms (*Agrostis* sp. and *Peridroma saucia*) feed on seedlings and can cause stand loss. Cutworms tend to migrate into a crop from field margins and feed at night, cutting seedlings at the soil level.

The cabbage aphid (*Brevicoryne brassicae*) and the turnip aphid (*Hyadaphis erysimi*) can contaminate heads and must be controlled during head development. The green peach aphid (*Myzus persicae*) can build to damaging levels on leaves of young plants; however, economic damage is rare on older plants unless contamination of the harvested broccoli becomes an issue. Aphids are attacked by generalist predators and parasitic wasps, which can help suppress aphid populations if insecticides do not impede them. It is important to scout for parasitized aphids, or aphid "mummies," which are dead, dry, tan-to-brown, "ballooned" aphids. In cool, wet periods, entomopathogenic fungi can also suppress aphid populations.

Several species of worms, such as loopers (cabbage looper: *Trichoplusia ni* and alfalfa looper: *Autographa californica*), beet armyworm (*Spodoptera exigua*), diamondback moth (*Plutella xylostella*), and others are potential problems, depending on the time of year and weather conditions. These caterpillars feed on foliage and they can infest and damage the broccoli head. All three types of caterpillars are attacked by parasitic wasps in the egg and larval stages. Pupal parasitism of diamondback moth larvae and imported cabbageworm larvae can also be significant. Predators and tachinid flies are significant mortality agents of caterpillars attacking broccoli. Insect pathogens, such as a nuclear polyhedrosis virus that attacks cabbage looper, can also help suppress caterpillar populations. Field scouts should look for evidence of natural enemy activity when monitoring aphids and caterpillars in broccoli. Worms should be managed by using selective insecticides to avoid making other insect problems more severe.

Figure 9. Sparse stand of broccoli that was damaged by feeding of cabbage maggots.

The silverleaf whitefly (*Bemisia tabaci*, biotype B) can cause significant damage to fields in the southern desert valleys if not controlled, but only isolated incidences have been observed elsewhere in the state.

Early-season plantings in the southern desert and the San Joaquin Valley are more likely to be attacked by seedling pests and worms than are late-season plantings. Broccoli planted in the coastal valleys must be monitored for insect pests on a year-round basis to determine if population pressures warrant an insecticide application. General UC recommendations discourage heavy use of broad-spectrum insecticides because they destroy the complex of beneficial insects that often keep pest populations in check. Use of selective materials can prevent nontarget effects of applications. Rotation of insecticide modes of action is essential for insecticide-resistance management. Heavy reliance upon a single mode of action and repeated use helps create resistance issues.

Bagrada bug (*Bagrada hilaris*) can be a serious pest in some parts of the state, in particular for newly planted or young broccoli plantings. It can cause serious crop loss, especially in organic production.

Nematodes and disease management

Soilborne pests that are potentially significant include the cyst (*Heterodera* sp.) and root knot (*Meloidogyne* sp.) nematodes and the fungal pathogen *Plasmodiophora brassicae*, which causes clubroot disease. Wirestem disease of transplants (*Rhizoctonia solani*) and white mold on older plants (*Sclerotinia sclerotiorum*) are occasionally seen on broccoli. These soilborne problems can be controlled by field selection, crop rotation, soil fumigation and, for club root, applications of lime to raise soil pH above 7.3. Seedling damping-off disease caused by *Rhizoctonia solani* occurs sporadically and is managed by cultural practices such as avoiding excessively wet soils during early stages of seedling growth and not transplanting too deeply.

Downy mildew (*Hyaloperonospora brassicae*) is a common oomycete (fungal-like) disease in broccoli. Though symptoms (leaf spots and foliar damage) are obvious in the field, economic loss is rare unless young seedlings are severely attacked or the disease becomes systemic in mature heads. Chemical treatment is usually only necessary to protect young seedlings during wet weather that favors disease. Other leaf-spot diseases such as Alternaria leaf spot (*A. brassicae* and *A. brassicicola*), bacterial blight (*Pseudomonas syringae* pv. *alisalensis*), and bacterial leafspot (*Pseudomonas syringae* pv. *maculicola*) occur on broccoli but are not usually economic concerns. The bacterial blight and bacterial leafspot pathogens occasionally cause broccoli head rot (described below).

The broccoli head is susceptible to several diseases that affect the immature flower buds, causing discoloration, rot, or both. Head rot diseases are favored by cool, wet weather conditions and are usually spread by splashing water. Bacterial head rot is caused by a complex of pathogenic bacteria species (*Pectobacterium carotovora* subsp. *carotovora*, *Pseudomonas fluorescens*, *P. marginalis*, *P. viridiflava*, and others). Alternaria head rot is a fungal disease caused by the same two species of Alternaria that infect leaves; both species can be seedborne. All of these problems can cause economic loss in broccoli and controlling them with pesticides has not been successful.

Abiotic disorders

Abiotic disorders on broccoli can be major obstacles to producing a high-quality, defect-free broccoli crop. Brown bead can be a serious production issue in broccoli fields. It is a physiological disorder that causes small areas (0.5 in, 1.2 cm) on the apical portion of the branches of the developing head to turn yellow, then brown (Jenni et al. 2001) (fig. 10). It resembles head rots, caused by bacterial and fungal infections; however, head rot lesions are typically water-soaked and moist, while brown bead lesions are dry. Brown bead also typically occurs during the warmer times of the year, while head rot occurs during the cooler, wetter times of year. Hollow stems is the result of cracking on the inside of the main stem of broccoli heads. It is an undesirable defect resulting from rapid growth of the heads. The incidence of hollow stems can be aggravated by several factors that facilitate rapid growth, such as high soil nitrogen levels, warm weather conditions, and wide plant spacing that allows plants to get abnormally large. Some varieties are more susceptible to hollow stem than others. Blind broccoli is a disorder that causes young plants with two to three true leaves to stop developing. The apical meristem stops growing. This is a physiological disorder that is poorly understood but has been shown to be associated with low light conditions in greenhouse production in other parts of the world. Various disorders affect the quality of broccoli heads, such as uneven bead size, yellow beads, bracts in the heads, and poor head shape. Uneven bead growth is often associated with high heat during the early development stage of the heads (Björkman and Pearson 1998).

Figure 10. Brown bead of broccoli heads causes dry necrotic areas on the heads.

Harvesting and handling

Broccoli is grown for both fresh and processed markets. Fields are harvested when a good number of heads have achieved marketable size (fig. 11). Broccoli is typically harvested by a crew consisting of cutters who select and cut harvestable heads and place them on a harvest platform, where packers make bunches, place heads into boxes, or both (fig. 12). Market price sometimes determines how broccoli is harvested—a crop may be hand-harvested two to three times depending upon market price and quality. Value-added fresh broccoli products range from special crown cuts, spears, and fresh florets to broccoli slaws for use in prepacked and other

Figure 11. Broccoli fields are ready for harvest when a large percentage of the heads are of marketable size.

Figure 12. A broccoli harvest operation consists of cutters selecting marketable heads and placing them on the platform, where they are placed in boxes.

convenience-food items destined for export, food service, and domestic consumers. California broccoli is exported to Japan and other Pacific Rim markets that require special harvesting of crown-cut heads, which are sold for higher prices (fig. 13).

Fresh-market broccoli is field-packed. Good-quality broccoli should have dark or bright green closed beads (flower buds). The head (florets on a fleshy stalk) should be compact (firm to hand pressure), with a cleanly cut stalk of the required length. The standard pack consists of heads that average 3 to 8 inches (7.5–20 cm) in diameter. Crews cut the stems at 8 inches (20 cm) and place the heads on a harvest-aid belt. Two to four heads are bunched by securing with a rubber band and are cut to a uniform 7 inches (17.5 cm). Fourteen or eighteen bunches of broccoli are packed in a waxed-fiberboard carton that weighs a minimum of 23 pounds (10.4 kg). Crown-cut broccoli consists of a top dome measuring 5 to 5.5 inches (12.5–13.7 cm) in diameter, cut from the stem at 5 inches (12.5 cm). A packed carton consists of 34 to 38 bulk-packed crowns and weighs a minimum of 20 pounds (9 kg). Field-cut florets are packed in totes and transported to packing facilities. There, they are loosely packed in bags and packed into cardboard cartons that weigh 9 to 18 pounds (4–8 kg) and contain three to four bags each. Broccoli destined for the freezer is also hand-harvested. The stem is cut at 6 inches (15 cm), slightly shorter than for the fresh market. The heads are placed on belts, then collected into large bins or trailers and hauled to the processor.

Postharvest handling

Broccoli requires rapid cooling to preserve quality and maximize shelf life. Harvested cartons should be taken immediately to the cooler and never allowed to sit for extended periods on the dock before cooling. Liquid icing of the field-packed waxed cartons is the standard cooling method. Immediately after icing, broccoli should be put in refrigerated storage. Hydrocooling and forced-air cooling also can be used, but temperature management during distribution is more critical than with iced broccoli.

Figure 13. Broccoli box packed with crown cuts destined for export markets in the Pacific Rim.

Low temperature is extremely important for achieving adequate shelf life in broccoli. A temperature of 32°F (0°C) with relative humidity of 95 percent or higher is required to optimize broccoli storage life (21–28 days). If heads are stored at 41°F (5°C), their shelf life is cut in half (10–14 days). Broccoli is extremely sensitive to exposure to ethylene. Floret (or bead) yellowing is the most common symptom. The beads are the most perishable part of the broccoli head; yellowing of the beads may be due to overmaturity at harvest, high storage temperatures, or exposure to ethylene. Any development of yellow beads ends commercial marketability.

For more detailed information about maintaining postharvest quality, visit the "Produce Fact Sheets" section on the website of the UC Davis Postharvest Technology Research and Information Center.

Marketing and sales

Approximately 95,000 acres (38,475 ha) of broccoli were grown in California in 2021 for the fresh market and lightly processed (florets) market, with a value of $631 million. California produces more than 89 percent of the broccoli grown in the United States, with Arizona producing 10 percent. However, given new heat-tolerant varieties and more efficient production and harvesting technologies, broccoli production is expanding in other states, especially along the Eastern Seaboard, where access to large markets is available. Exports of broccoli have strengthened the market for California broccoli. For instance, 15 to 20 percent of California's fresh-market broccoli production is exported, with about 50 percent of those exports going to Canada, about 35 percent to Japan, and about 10 percent to Taiwan.

Demand for broccoli is steadily increasing, both domestically and internationally. Broccoli demand is attributed to health-related issues and matters of convenience. The salad bar trend in the early 1980s started the rise in per capita consumption. Nutrition information from the U.S. Department of Agriculture indicated that the fiber content of broccoli is among the highest of all vegetables and that broccoli is a good source of vitamin C and beta-carotene. The highly publicized medical research linking sulforaphane compounds in broccoli with strong anticancer activity in the body has added a powerful incentive to consumption. The introduction in the mid-1990s of precut, packaged, value-added products, such as bagged precut florets, diced broccoli pieces, and stir-fry mixes, provided more convenience for domestic consumer markets, food service, and export.

Innovative products like broccoli coleslaw and mixes with other vegetables are also helping to expand total broccoli use.

Cost of production

Cost-of-production studies show the profitability of producing broccoli. That said, broccoli production is cost- and labor-intensive, especially in harvesting and postharvest handling. In cost studies completed in 2023 for bunched and crown-cut broccoli in Monterey, Santa Cruz, and San Benito Counties, harvest and postharvest costs accounted for 64 to 69 percent of the total production cost for broccoli, whereas the total growing cost accounted for 31 to 36 percent (Tourte et al. 2023a and Tourte et al. 2023b).

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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 UC ANR Associate Editor for Vegetable Crops Scott Stoddard.