SUMMER SQUASH PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

Fresh market summer squash (*Cucurbita pepo)* production can be found in almost all areas of California, particularly in the southern desert areas of the Imperial Valley, the Central Valley from Kern to Merced Counties, and the south-central coast from Santa Barbara north. Summer squash, which are eaten immature, include zucchini, crookneck, straightneck, and scallop types. The main production occurs in the spring and summer months. Acreage is significantly reduced in the fall when plants are damaged by aphid-transmitted viruses and silverleaf whitefly problems. Counties with the largest acreage of summer squash in 1996 included Santa Barbara, Fresno, Riverside, San Luis Obispo, Monterey, and Orange.

SUMMER AND WINTER SQUASH ACREAGE AND VALUE

Year	Acreage	Average yield (*tons/acre*)	Gross value/acre
1996	7,338	9.8	$3,836
1995	5,478	11.2	$3,983
1994	7,905	9.9	$3,498

Source: Annual California Agricultural Commissioners' Report (Sacramento: Calif. Dept. of Food and Agriculture, 1994–96).

CLIMATIC REQUIREMENTS

Summer squash is a warm-season crop that will grow in nearly all climates of California. Since summer squash is a short-season crop, it thrives in somewhat cooler climates better than other cucurbits such as cantaloupe and watermelon. Although summer squash production often slows in cool climates, virus pressure is often lower, with improved yield and quality. The seedlings are subject to frost damage. For early-spring squash in the southern desert valleys, the seed can be planted in December and January. The optimal germinating temperature range is 70° to 95°F (21° to 35°C), and the maximum germinating temperature is 100°F (38°C). Below 60°F (15.5°C) germination may take as long as 2 weeks. In the Central Valley, planting may start as early as mid-February with cold protection (plastic tunnels) and from March 1 to March 15 without cold protection. The optimal growing temperature range is 65° to 75°F (18° to 24°C).

VARIETIES

Zucchini, the most popular type of summer squash, can be found in dark, medium, and light green colors, as well as yellow-orange. Zucchini grows to maturity in about 60 days. The fruit vary greatly in length but are generally long and cylindrical with the stem end about equal in width to the blossom end. Dark green types include Ambassador, Aristocrat, Black Jack, Dividend, Elite, Onyx, Raven, and Revenue. Medium green types include Embassy, Spineless Beauty, Senator, and President. Greyzini is a light-green type, and yellow types include Gold Rush, Golden Dawn, Gold Finger.

Other summer squashes, which take about 55 days to grow to maturity, include yellow straightneck, yellow crookneck, and scallop squashes. Yellow straightneck types include Multipik, Superpick, and Golden Girl; these fruits have yellow skin and generally have a straight crook only slightly narrower than the blossom end. Some yellow straightneck varieties have a more pronounced crook than others. Yellow crookneck types include Destiny, Freedom, Goldie, Sundance, Supersett, and Sunrise; these fruits are generally cylindrical at the blossom end, narrowing to a slender neck at the stem end. Scallop types include Early White Bush, Peter Pan, Scallopini, Sunburst, and Bennings Green Tint; these fruits are white, yellow, or green, and they resemble a scallop shell, wider than thick. This type of squash is often referred to as "summer squash," especially by Spanish-speaking people.

Some squash varieties, such as Dividend, have resistance to certain viruses. This resistance may be the result of natural resistance through normal hybridizing or through bioengineering (gene insertion on a protein coat). Other varieties of summer squash, such as Multipik, are listed as "precocious." These fruits start out yellow instead of green. The precocious gene also provides for some degree of tolerance to watermelon mosaic virus II (WMV II) by masking the mosaic symptoms for a short

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time. Eventually the fruit displays the virus symptoms and later becomes unmarketable. Fruit stems are also yellow instead of green.

CULTURE

Squash plants have an extensive root system, up to 4 feet (1.2 m) deep, with the majority of the roots in the top 12 to 18 inches (30.5 to 45.5 cm) of soil. Direct seeding is preferred over transplants since squash is very sensitive to transplant shock, but transplants can be used successfully if they are not allowed to remain in the greenhouse for too long. Squash seed remains viable for as long as 4 years if stored in a cool, dry place. Growers commonly plant 4 to 6 pounds of seed per acre (4.5 to 6.7 kg/ha). This allows for one seed every 9 to 12 inches (23 to 30.5 cm) on beds that are 5 feet (1.5 m) wide. Plants are later thinned to 12 to 15 inches (30.5 to 38 cm) between plants. The seed is planted 1 to 1.5 inches (2.5 to 4 cm) deep.

In the desert areas of California, spring-planted squash is grown on slanted beds 60 inches (1.5 m) wide. Rows are oriented east to west and the beds are slanted facing south. Heat is further directed to the seedline with brown kraft wrapping paper that is supported by stakes and slanted to reflect heat toward the seed. The paper also acts as a windbreak. Black plastic mulch can also be used to warm the soil. With black plastic mulch, the beds are not slanted, and kraft paper is also used.

In the Central Valley seed are planted in clear plastic tunnels or hotcaps in beds spaced 5 feet (1.5 m) apart for early- spring crops. It is generally considered to be safe to plant seed after March 15 with no frost protection. Instead of 5-foot beds, some growers make beds on 36- to 40-inch (0.9- to 1.0-m) centers and plant every other row. This allows them to use the same bed spacing for other vegetable crops. Tunnels of clear plastic polyethylene film, usually 1.5 mils thick, are stretched over frames constructed of heavy-gauge wire hoops. The tunnels must be vented on warm days to keep the plants from scorching. Drip irrigation is often used in conjunction with tunnels. Fall crops in the San Joaquin Valley run the risk of virus problems jeopardizing potential profits.

SOILS

Well-drained soils favor squash production. The optimal pH is 5.8 to 7.0; limestone or sulfur can be used to adjust the pH if needed. Sandier soils require more frequent watering and fertilization than heavy-textured clay soils.

IRRIGATION

Squash roots develop rapidly, with roots in the top 18 inches (45.5 cm of soil. Irrigations should be scheduled to avoid excessive moisture or water stress. In the San Joaquin Valley, if the clay or loam soil is moist to at least 4 feet (1.2 m) at planting, the soil has sufficient moisture to carry the crop well into the growing season. In the Coachella Valley, spring squash that is grown on black plastic mulch is usually drip-irrigated. Spring squash grown on slanted beds is usually furrow-irrigated.

Early-season irrigation tends to cool the soil and slow plant growth. At least 18 acre-inches (1,854 m) of water is required for the season. The California Irrigation Management Information System (CIMIS) can help provide evapotranspiration (ET) rates to help with irrigation scheduling. Generally, 1 acre-inch (103 m) of water is applied at each irrigation. Sandy soils require more frequent irrigations than clay soils. Lack of adequate moisture at harvest can result in misshapen fruit; too much moisture can aggravate root and stem rot diseases.

FERTILIZATION

Nitrogen (N) fertilizer is needed to produce maximum summer squash yields. A soil test will help to determine specific nutrient needs, but the following general guideline can be used. If the soil is cold (50° to 60°F [10° to 15.5°C]), as is often the case with early-spring plantings, apply about 60 pounds per acre (67 kg/ha) of nitrogen (N) and 20 to 25 pounds per acre (22.5 to 28 kg/ha) of phosphorous (P) before planting. Broadcast the preplant fertilizer and till it into the bed or band the fertilizers 3 to 4 inches (7.5 to 10 cm) below the seedline and offset slightly toward the water furrow. The total recommended amounts of fertilizer for the crop are 80 to 150 pounds per acre (90 to 168 kg/ha) of nitrogen; 60 to 120 pounds per acre (67 to 134 kg/ha) of phosphorous (P_2O_5); and 0 to 150 pounds per acre (0 to 168 kg/ha) of potassium (K_2O). Sidedress with the remaining nitrogen when the plants are 3 to 5 inches (7.5 to 12.5 cm) tall. Do not apply more than 60 pounds per acre (67 kg/ha) of nitrogen in any fertilizer application. In drip systems, the nitrogen amount can be broken into three to four smaller applications.

POLLINATION AND FRUIT SET

Squash is monoecious (the male and female flowers develop on the same plant). During the main growing season the ratio of male to female flowers is usually 3:1 or higher. The female flower is distinguished by the presence of an ovary at the base; female flowers are borne on very short stems, and male flowers are borne on long stems. Honey bees are the primary pollinators, and 1 to 2 hives of bees per acre (2.5 to 5 per ha) should be provided for a good fruit set. Poor pollination results in small young fruit that turn yellow, shrivel, and fall off. Incomplete pollination may also cause misshapen fruit that are unmarketable. Squash fruit grow about 0.75 to 1 inch (1.9 to 2.5 cm) per day. Cross-pollination between the same species of squash can occur (for example, between zucchini and crookneck), but this is not a concern unless the crop is being grown for seed production. Cross-pollination does not occur between cucurbits of different species (for example, between zucchini and cucumber).

INTEGRATED PEST MANAGEMENT

Detailed information about integrated pest management (IPM) for squash is available from the UC Davis IPM World Wide Web site at http://www.ipm.ucdavis.edu, by contacting your local county Farm Advisor, or by consulting the cucurbit guideline in *UC IPM Pest Management Guidelines* (DANR Publication 3339).

Insect Management. Seedcorn maggot larvae (*Delia platura*) feed on germinating squash seed. High levels of decaying organic matter in the soil may encourage seedcorn maggots. Wireworms (*Limonius* spp. and others) can kill young plants and weaken older ones by feeding on the root system. Squash bugs (*Anasa tristis*) have sucking mouthparts and can kill squash leaves and vines. Eggs of squash bugs, which are barrel shaped and reddish-brown, are laid on the undersides of leaves.

Whiteflies can also destroy squash plants with their feeding. The silverleaf whitefly *(Bemisia argentifolii)* was named for the physiological disorder it causes in various cucurbits, a "silvering" of the leaves caused by the feeding of only a few of the young. Feeding whiteflies suck plant sap, resulting in silvering, defoliation, stunting, and poor yields. Sticky honeydew is excreted by the whitefly, promoting the growth of a black sooty mold. The greenhouse whitefly (*Trialeurodes vaporariorum*) can also feed on and damage squash. The melon aphid (*Aphis gossypii*) and the green peach aphid (*Myzus persicae*) also cause problems by weakening the plant through feeding and are also vectors of many virus diseases (see below).

Leafminers (*Liriomyza* spp.) may damage newly emerged cotyledon leaves. The population of natural predators is usually adequate to control leafminers if not disrupted by insecticide applications. Western spotted (*Diabrotica undecimpunctata undecimpunctata*) and striped (*Acalymma trivittatum*) cucumber beetles can attack squash in large numbers and feed on young and older plants. Their larvae feed on the roots and underground parts of the stem. Larvae of several species of armyworm (*Spodoptera* spp.) and the cabbage looper (*Trichoplusia ni*) can also feed on squash foliage.

Disease Management. Powdery mildew (*Erysiphe cichoracearum*) is common in squash fields throughout the growing season. This fungal disease can be a problem at any time in coastal growing areas and can be a problem in late summer and fall in the inland valleys. Gummy stem blight (*Didymella bryoniae*) can cause serious problems on stems, leaves, and fruit of squash. This disease is often first noted as a developing rot in the lower vine stem area, but it also may affect foliage. Charcoal rot (*Macrophomina phaseoli*) affects squash and other cucurbits. Leaves of the crown area turn yellow and wither. The causal organism, a soilborne fungus with a wide host range, is common in most soils in the Central Valley. Phytophthora root rot (*Phytophthora capsici, P.* spp.*)* is a serious disease of squash, especially where soils are wet for extended periods. *Phytophthora* may cause root rot, stem lesions, or foliar blight. Fusarium crown and root rot *(Fusarium solani* f. sp. *cucurbitae)* may affect the lower stem or crown area, causing plants to wilt and die. The fungus survives on soil and seed and is most common on the Central Coast. Fungal diseases of squash are controlled by combinations of cultural controls, such as long-term rotation out of cucurbits (4 years or more), the use of clean seed, and chemical controls; for more information, see the sources listed at the beginning of this section.

Some of the most serious disease problems with squash, as with many cucurbits, are caused by viruses. Viruses cause mottling and distortion of leaves and fruit. Aphids and whiteflies can transmit viruses from surrounding fields and weeds to the very young emerging cotyledon leaves. Virus transmission is vector-specific: for example, a virus such as cucumber mosaic virus (CMV) is transmitted only by aphids. Viruses such as CMV, watermelon mosaic virus (WMV), zucchini yellow mosaic virus (ZYMV), and papaya ringspot virus (PRV) are transmitted by aphids in a nonpersistent manner (requiring only seconds to a few minutes for the aphids to probe the leaf surface and transmit the virus). It is very difficult to visually identify the particular virus strain, and positive identification is possible only through laboratory analysis. To complicate the identification process, it is not uncommon to find two, three, or four viruses infecting a squash field at the same time. There are no chemical tools available to control viruses. Some control is possible through management of the insect vector. Systemic insecticides can be applied at planting to control insect pests, and reflective plastic mulches have been used with some degree of success. Some squash resistance to one or several viruses can be found in some varieties, and the possibilities of resistance are increasing each year.

Weeds. Weeds can cause yield reductions, especially if left uncontrolled early in the season. In addition, weeds interfere with harvest by making fruit difficult to find. The vigorous growth of many cucurbits makes integrated weed management feasible. An integrated approach is necessary because of the limited availability of registered and effective selective herbicides. Avoid fields that have high populations of certain weeds such as common purslane (*Portulaca oleracea*), field bindweed (*Convulvulus arvensis*), or nutsedge (*Cyperus* spp.), as these weeds are not adequately controlled by registered chemicals or nonchemical methods. When squash is sown during cooler seasons of the year, it grows more slowly and is less competitive against weeds. During cooler seasons squash needs a more diligent weed control program for optimal yield and quality. Just before planting cucurbits, preirrigate the field to germinate weed seeds and cultivate to destroy them. Black plastic mulch is frequently used to warm the soil and help control weeds.

Nematodes. Nematodes are microscopic roundworms that live in soil and plant tissues. Plant-parasitic nema-

todes feed on plants by puncturing cells and sucking their contents with a needlelike mouthpart called a stylet. All cucurbits are susceptible to root knot nematodes (*Meloidogyne* spp.). Damage is typically greatest in warm regions with light, sandy soils. Nematode-infested plants may have reduced growth and lower yield and fruit quality, and they tend to wilt earlier under moisture stress. For information on control, see the sources listed at the beginning of this section.

HARVESTING AND HANDLING

Summer squashes are usually eaten at immature stages, as opposed to the hard or winter types, which are eaten when the fruit is mature; the male flowers are also harvested and sold. Summer squash fruit is generally harvested when the rind is still tender and the seeds are immature. Care should be taken not to injure the soft skin. Wearing gloves can reduce damage to the fruit by fingernails. A clean, dry rag may be used to clean dirt and dust off the fruit. Depending on the variety, fruit reach harvestable size 4 to 8 days after pollination. If fruit is allowed to remain on the plants too long before picking, the plants tend to set fewer fruit. Harvests every other day (depending on the temperature) are common for up to several months. Zucchini and straightneck fruits are more desirable at 5 to 6 inches (12.5 to 15 cm) long for western markets and 7 to 8 inches (18 to 20.5 cm) long for eastern markets. Crookneck, straightneck, and zucchini fruits should be 1.25 to 2 inches (32 to 51 mm) in diameter. Specific sizing and maturity may vary depending on the market.

Fruit is hand-picked into containers and usually sorted, graded, and packed in the field. Fruit should be cooled to 50°F (10°C) as soon as possible. Delaying cooling adversely affects fruit quality and shortens the shelf life. The yield depends on the number of harvests and the size of the fruit; selecting small squash reduces the overall yield. Most fields exceed 1,000 cartons per acre, but yields of 2,400 cartons per acre have been reported. Zucchini are usually packed in 28-pound cartons, while scallop squash are packed in 26-pound cartons.

POSTHARVEST HANDLING

Fresh market summer squash should be stored at 41° to 50°F (5° to 10°C) and 95 percent relative humidity. The storage life is usually less than 10 days, although zucchini has been stored at 41°F with acceptable market quality for up to 2 weeks. Storage at below 41°F for 1 to 2 days generally results in chilling injury, though varieties differ in their sensitivity. Chilling injury is seen as pitting on the surface, discoloration, and accelerated decay. Storage in low-oxygen atmospheres is of little or no value. Summer squashes are low to moderately sensitive to ethylene gas; accelerated yellowing of green types results from exposure to low levels of ethylene. Additional information on postharvest handling can be obtained from the UC Davis postharvest website at http://postharvest.ucdavis.edu.

MARKETING

Florida is the leading state in summer squash production, and California is second. Other states of importance are Texas, New Jersey, Massachusetts, New York, Michigan, Georgia, Oregon, and South Carolina. Typically, zucchini is marketed according to one of three sizes (according to U.S. #1 grade standards) in a 28-pound box: Extra Fancy, 5" to 6" length and 1" to 1.5" width; Fancy, 6" to 7" length and 1.25" to 1.75" width; and Medium, 7" to 8" length and 1.75" to 2.25" width. Prices reported paid at the Los Angeles terminal market were highest in mid-March after zucchini shipments from Mexico declined, and high again from October through December. A specialty market also exists for “baby” type summer squashes that are harvested at a very small immature stage and sometimes sold with the flowers attached.

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