VEGETABLE RESEARCH AND INFORMATION CENTER

Vegetable Production Series

CUCURBIT SEED PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

California is a major world producer of many cucurbit seed crops, including cucumber (*Cucumus sativa*); cantaloupe and mixed melons (*Cucumus melo*); squash, pumpkin, and gourds (*Cucurbita* spp.); and watermelon (*Citrullus lanatus*). The majority of the production occurs in the lower Sacramento Valley, with Colusa, Sutter, and Glenn Counties producing more than 80 percent of the state total. A limited production also exists in the San Joaquin and Imperial Valleys.

In the lower Sacramento Valley, planting begins in May and extends into early July for harvest from mid-August through mid-October. The times from plant emergence to harvest are 78–90 days for cantaloupes and mixed melons; 85–100 days for watermelons; 100–120 days for summer squashes; 120–130 days for cucumbers; and over 130 days for winter squashes.

CUCURBIT SEED ACREAGE AND VALUE

Year	Total acreage	Total crop value (*$ million*)
1995	19,600	20.9
1994	18,000	19.9
1993	24,100	30.7

Source: California Agricultural Commissioners' Report Data (Sacramento: California Department of Food and Agriculture, 1994–1996).

CLIMATIC REQUIREMENTS

Cucurbits are warm-season plants that grow best from 70° to 90°F (21° to 32°C). Freezing kills the plants and cool weather below 60°F (16°C) slows or stops growth. Cucurbit seed germinate and emerge in as little as 4 days at a soil temperature of 77°F (25°C) and from 6 to 12 days at 68°F (20°C). Most cucurbit seed do not germinate well below 60°F (16°C). Cucurbit seed is relatively vigorous, and stand establishment is not a problem if proper soil preparation, temperature, and moisture conditions are met.

PLANT AND FLOWER DEVELOPMENT

Cucurbit flower buds begin to appear several nodes above the cotyledons and develop into either male (staminate or pollen-producing) or female (pistillate or fruit-producing) flowers. In cantaloupes, mixed melons, and watermelons, both male and perfect flowers (having both pollen and fruit in the same flower) are produced. The first flowers formed are usually male. The plant produces many more male than female or perfect flowers to ensure an ample supply of pollen throughout the flowering period. Female flowers appear after the early flush of male flowers. Following pollination, seed develop within the fruit of the fertilized female or perfect flowers.

POLLINATION

Cucurbits require that pollen move from staminate to pistillate flowers or from the anthers to the stigma of perfect flowers. Honey bees are the most reliable and cost-effective way to achieve pollination. One to two hives per acre are introduced when 5 to 10 percent of the plants have open flowers. If hives are placed in weedy areas or close to other flowering crops, the number of hives per acre should be increased. Hives should be placed in clusters around the periphery of fields, with additional hives placed inside of larger fields. Further information is contained in DANR Publication 7224, *Honey Bee Pollination of Cantaloupe, Cucumber, and Watermelon*.

VARIETIES AND PLANTING TECHNIQUES

F_1 hybrids dominate the market for most commercial cucurbit crops due to their greater vigor, higher yield, and greater uniformity than open-pollinated varieties. In addition, since parent lines are proprietary and seed cannot be propagated for a second generation from hybrid seed, seed company investments in varietal research and development are more secure.

Hybrid seed production is common for cucumbers and summer squashes and represents the bulk of seed produced for these crops. In hybrid cucumber production, genetic manipulation is used to grow plants having only female flowers (gynoecious plants). These plants will be hybrid "mother plants." Adjacent rows are planted with normal genotypes to provide pollen, and bees transfer the pollen from the male flowers to the female flowers.

In hybrid squash production, ethylene-releasing compounds suppress male flower production; the treated plants will produce mostly female flowers. Adjacent rows of the male parent lines are not sprayed. In both the genetic and chemical methods, only the female rows are harvested for hybrid seed.

Hybrid seed production by these methods is not currently feasible for cantaloupes, mixed melons (honeydew, crenshaw, casaba), or watermelon because they have bisexual flowers. Hybridization of these crops requires extensive hand labor. As a result, hybrid seed production occurs outside the United States, where labor is relatively inexpensive and abundant.

Vineseed crops are direct seeded. Plants are grown on raised 60-inch (1.5-m) beds, with either a single row down the middle of the bed (vine types) or two rows, each 6 to 7 inches (15–17.5 cm) off the center of the bed (semi-determinate types). Optimum in-row spacings, with the number of plants per acre in parentheses, are: double-row summer squash, 6 to 8 inches (15–20 cm; 26,000–35,000); single-row cantaloupe or double row cucumber, 10 to 12 inches (25–30 cm; 8,700–10,500/17,500–21,000); single-row winter squash or pumpkin, 10 to 14 inches (25–35 cm; 7,500–10,500); and single-row watermelon, 12 to 24 inches (30–60 cm; 4,500–9,000).

Seed are typically planted 1 to 2 inches (2.5–5cm) deep into preirrigated beds. To achieve simultaneous flowering of both hybrid parents ("nicking"), the male and female rows are often sown on different dates. Hybrid fields are typically planted in a three-row female to one-row male pattern repeated throughout the field.

SOILS

Cucurbits grow in a wide range of soil types but do best in well-drained soils with good physical characteristics. In the Sacramento Valley, the crops are grown predominately on clay and loam soils that require careful irrigation management to obtain high-yielding seed crops.

Most cucurbits are moderately sensitive to salt, displaying a 50 percent yield reduction in the range of ECe 4 to 6 (mmhos/cm at 25°C). Cucurbit salt tolerance decreases in the following order: winter squash or pumpkin; watermelon or mixed melons; summer squash; cucumber.

IRRIGATION

Most cucurbit seed fields are furrow-irrigated, but sprinklers may be used for stand establishment. Season-long sprinkling is discouraged, especially for cucumbers, due to the possibility of foliar diseases. Regardless of the irrigation method, monitoring the efficiency and uniformity is essential.

A "water-budget" approach, where water that is lost to soil evaporation or plant transpiration is replaced as needed, works well. This method requires knowledge of soil water-holding abilities, rooting depth, and plant foliage development, as well as daily evapotranspiration values (see DANR Publication 21414, *How Farmers Irrigate in California*). The objective is to replace the water used without allowing the plants to be stressed.

Irrigations should be scheduled every 6 to 10 days during the hottest part of the year when plants have the most foliage. Earlier in the season, when the plants are smaller, or later, when they are mature, irrigation should be less frequent. Differences in rooting depth and plant foliage density between vineseed plants must also be considered. Cucumbers and summer squashes generally have more modest root systems than the other crops and therefore require more frequent, lighter irrigations. Crop planting and maturity dates also influence total water needs.

FERTILIZATION

Fertilizer requirements depend on the nutritional status of the soil. A preplant soil analysis for the macronutrients, except nitrogen (N), and any minor nutrients of concern is recommended as the basis for planning the crop's fertilizer program.

Cantaloupe seed crops typically demonstrate an economical N response to 60 to 100 pounds per acre (67–112 kg/ha). Long-season crops such as cucumbers may require as much as 125 to 150 pounds per acre (140–168 kg/ha) of N. Half of the N should be applied preplant and the remainder about 5 to 6 weeks after seedling emergence. Phosphorous (P) or potassium (K), whose requirements are based on preplant soil tests, should be applied preplant.

Liquid starter fertilizers are commonly used at planting. These should be placed in a band 2 to 4 inches (5–10 cm) below and to the side of the seed row to prevent fertilizer burn and ensure that the developing roots can access the fertilizer. A typical rate and material would be 10-34-0 at 10 to 15 gallons per acre (93–140 l/ha). Potassium and chelated forms of micronutrients may be added to the starter fertilizer. Or, many micronutrients may be applied as a postemergence foliar spray if a deficiency is identified. Molybdenum deficiency, an occasional problem for cantaloupes or mixed melons, is easily corrected with a foliar application of sodium molybdate.

Petiole tests are recommended to determine postemergence N needs and to confirm adequate levels of the other essential nutrients (see DANR publication 1879, *Soil and Plant Tissue Testing in California*). Any additional N should be placed 6 to 12 inches (15–30 cm) from the plant row and about even with the bottom of the furrow. Care must be taken not to cause excessive damage to plant roots. Irrigation water should be supplied shortly after applying the fertilizer to move it toward the plant roots. Concentrated amounts of volatile materials, such as anhydrous ammonia, should be used with caution.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) depends on the judicious use of agrochemicals, production technology adjustments, the acceptance of tolerable levels of pest damage, and appropriate postharvest programs. Cucurbit pest management is covered in *UC IPM Pest Management Guideline* 27, *Cucurbits*, which may be obtained by accessing the UC IPM World Wide Web site at http://www.ipm.ucdavis.edu.

Weed management. Although registered herbicides can control most grassy weeds in cucurbit crops, few broadleaf herbicides are currently available for use in California. Control strategies often rely on mechanical cultivation, weed exclusion, and hand weeding. Many vineseed crops are densely planted and may require thinning after emergence, which also provides an opportunity for weed removal. The vining growth habit of cucurbits allows them to compete well with weeds once the crop is established.

Disease management. Damping-off (seedling mortality caused by *Phytophthora*, *Fusarium*, *Pythium* and *Rhizoctonia* fungi) can be a problem in cool, moist soils. Later in the season, *Fusarium* wilt in watermelon, *Phytophthora* root rot in winter squash and pumpkin, or fruit rots caused by fungi can be problems. These can often be avoided or minimized by proper irrigation management and preventing plant stress.

Viruses are the most serious diseases of vineseed. Foliar symptoms are light and dark green patches on the leaves, puckered leaf growth, and generally stunted plant growth. Affected fruit have raised, blistered areas, and variegated patches and are malformed. Plants infected early often fail to produce flowers or set fruit.

Common cucurbit viruses include watermelon mosaic (WMV II), papaya ringspot (PRSV-W), zucchini yellow mosaic (ZYMV), squash mosaic (SqMV), cucumber mosaic (CMV), and cucurbit aphid borne yellows (CABYV). SqMV is transmitted by cucumber beetles, and the others by several aphid species.

Chemical control is difficult because infection occurs immediately after an insect feeding event and the insects migrate freely between fields. A good control strategy is to maintain healthy and vigorous plants, monitor the fields often to detect unusual growth, correctly identify the disorder, and be flexible in determining the most appropriate solution.

Foliar diseases may also cause localized problems. Angular leaf spot (*Pseudomonas syringae*) on cucumbers is a seedborne bacterium that may be spread through sprinkler irrigation. Powdery mildew (*Erysiphe* or *Sphaerotheca* spp.) can be a late-season problem in cucurbits, but there is little evidence that it causes reduction in seed yield.

Bacterial fruit blotch (*Acidovorax avenae* ssp. c*itrulli*) has recently become a serious problem in some watermelon production regions, causing water-soaked lesions and loss of fruit quality. As the disease can be seedborne, close monitoring of seed production fields and testing for contamination are required for certified seed.

Insect management. The most serious insect pest of cucurbits is the western spotted cucumber beetle (*Diabrotica undecimpunctata*). This insect, known as the southern corn rootworm in its larval stage, may migrate from cornfields to adjoining cucurbit seed fields. The adult insect is about ¼ inch long (0.6 cm) and is lime-green with black spots over the wings and back. It causes damage in the seedling stage by girdling and weakening the stems. At flowering, the insects feed on flower parts and cause poor pollination or deformed fruit growth.

The melon or cotton aphid (*Aphis gossypii*) damages plants by feeding on plant parts, removing nutrients and transmitting viruses. Aphid feeding also results in honeydew (secretion) that causes mold growth and stickiness and may slow harvest. The green peach aphid (*Myzus persicae*) and other aphids are occasional pests as well. A key to successful aphid control is the early detection and treatment with appropriate insecticides. As naturally occurring parasites may aid in control, aphid populations should be closely monitored to determine if chemical treatments are warranted.

Squash bugs (*Anasa tristis*) primarily attack summer and winter squashes, as well as pumpkins, and favor weakened plants. They inject a toxin into the plant that causes distorted and/or diminished growth. Large numbers of squash bugs may be present on some plants and none on adjacent ones.

Effective chemical insecticides are registered for many of the important insect pests. Growers should schedule applications before placing bees in the field. Insect control options are severely restricted during the 3 to 4 week pollination period, so close insect monitoring and treatment (if necessary) should occur prior to that time. Maintaining vigorous plant growth helps minimize insect problems.

Abiotic problems. Blossom end rot in watermelon is a disorder related to calcium nutrition in the developing fruit. When growth is rapid, insufficient calcium may be delivered to the blossom end of the fruit, regardless of the calcium available in the soil. The problem, more common in varieties with elongated fruit shapes, may be minimized by careful irrigation to maintain a consistent water supply during fruit growth. Foliar sprays of calcium are not effective for control.

HARVESTING AND HANDLING

Vineseed crops are harvested when the majority of fruit are mature, as generally indicated by yellowing of the fruit. Optimal seed quality coincides with fruit maturity. Seed quality can decline if harvest is delayed, particularly if temperatures are high and the fruit are exposed to the sun. Sunburned fruit is an indication of high fruit temperatures, with the potential for seed damage.

Cucurbit seed is mechanically harvested with specialized equipment. In a destructive harvest, fruit are carried into the harvester on a chain conveyer and crushed to release the seed. The seed and pulp travel through an inclined rotating drum screen that allows the seed to fall through and carries the fruit rind, pulp, dirt clods, and trash out the rear of the harvester. Screens of various sizes are used for different vineseed crops. The seed are then augered from a storage hopper into bins for transport to a washer-dryer. To prevent contamination or mixing of seed lots, the harvester must be thoroughly cleaned between fields of different varieties or species.

Seed must be washed and dried promptly after harvest. Microbial fermentation begins immediately in the slurry and can result in elevated temperatures that are damaging to seed germination or vigor. The seed is washed by water sprays as it moves through inclined rotating drum screens. This removes additional debris and fruit juices and results in clean seed. The seed is then transferred to another rotating drum through which ambient or heated air is forced, depending on air temperatures. Seed contracts require that the final seed moisture be from 6 to 8 percent. Seed with more moisture than that do not store well, while drier seed may be physiologically damaged. It is critical that the moisture and temperature be measured frequently during the drying operation to prevent under- or over-drying. Seed temperature should not be allowed to exceed 95°F (35°C) during drying.

POSTHARVEST HANDLING

After the seed has been washed and dried, it is placed in plastic-lined bulk cardboard containers and transferred to the seed contractor. The seed is then cleaned, graded, and tested for purity and germination percentage. The presence of weed seed, variability in seed sizes, and excess foreign material can require additional seed cleaning or conditioning at the seed processing facility. After minimal contractual specifications are confirmed, the grower is paid for the final amount of clean seed. Payment can often be many months after harvest, so growers should be clear on payment schedules before accepting a contract.

MARKETING AND PRODUCTION COSTS

All cucurbit seed are produced under contracts with seed contractors. In the typical contract, the number of acres to be produced, the price per pound, and seed quality criteria are specified. All marketing is done by the seed contractor. Cucurbit seed from California is marketed to all foreign and domestic fresh-market cucurbit production areas.

Detailed production costs are outlined in the UC Cooperative Extension publication *Sample Costs to Produce Cucurbit Seed in the Sacramento Valley, 1997*, available from the University of California, Davis, Agricultural Economics Department or from county Cooperative Extension offices.

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