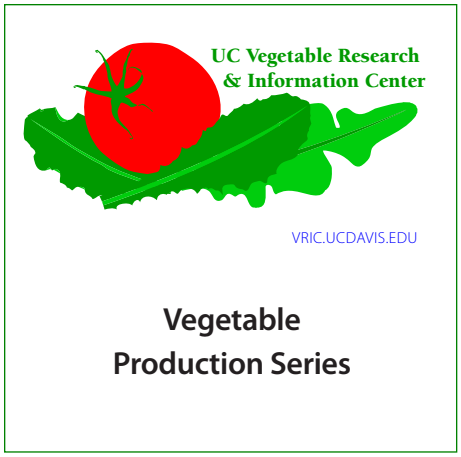

FRESH-MARKET BULB ONION PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

Fresh-market bulb onions (*Allium cepa* L.) are produced throughout California. The main production areas are the low desert (Imperial and Riverside Counties), the San Joaquin Valley (Fresno, Kern, and San Joaquin Counties), the southern and central coast (Monterey, San Benito, Santa Clara, and Ventura Counties), and the high desert (eastern Los Angeles County). Bulb onions are planted from September through May. Harvest begins in April or May and is usually completed in September. Fresh bulbs and lightly processed bulbs (fresh onion ring, whole-peeled, etc.) make up approximately 45 percent of the total bulb onion acreage in California, which ranks among the top fresh-bulb-producing states in the United States. Approximately 20 percent of California's fresh-market onions are stored for 3 to 6 months.

CLIMATIC REQUIREMENTS

Onions are cool-season biennial plants (requiring two seasons to complete the cycle from seed to seed) that are commercially grown as an annual crop. Bulbing is highly dependent on day length. Varieties adapted to California will initiate bulbing at day lengths of approximately 12 to 15 hours. Dozens of varieties are grown in California due to the great difference in latitude between the Mexican border (32°N) and the Oregon border (42°N), and because several market classes are needed.

Short-day onions are planted in the fall and bulb with 12 to 14 hours of daylight. They are adapted to the desert regions of Southern California. Using transplants, these varieties can be grown in the lower San Joaquin Valley and south coast, with a maximum latitude of approximately 36°N. Intermediate-day varieties are also planted in the fall. They are grown throughout the San Joaquin and Central Coast valleys and can be grown in the lower Sacramento Valley and central Sierra foothills. Day length requirements are approximately 13 to 15 hours, with optimal adaptation in latitudes of 35° to 38°N. As with the short-day types, varieties with a continuum of varying day lengths have been developed.

Onion growth is very dependent on temperature. The minimum temperature for emergence is higher than for most other cool-season vegetables at 55°F (12.8°C) for 70 percent emergence in up to 2 weeks. In addition, early growth rate is slow compared with other cool-season crops. Optimal leaf growth rate occurs at 68° to 77°F (20° to 25°C). However, total plant growth rate depends on the amount of light intercepted. Maximum light interception occurs with a leaf area index of approximately 8 or higher.

Bolting is primarily driven by temperature when plants with a leaf base greater than approximately ⅜ inch (9.5 mm) in diameter are subjected to temperatures of 45° to 50°F (7.2° to 10°C). A combination of factors, including planting date, variety, plant size, and temperature, as well as timing and duration of temperature, determine whether and when bolting occurs.

FRESH-MARKET BULB ACREAGE AND VALUE

Year	Acreage	Average yield (*tons/acre*)	Gross value/acre
2009	22,766	27.22	$6,821
2008	22,512	24.05	$5,298
2007	25,318	25.39	$6,289
2006	25,981	23.05	$7,114

Source: Compiled from agricultural commissioner reports for Fresno, Imperial, Kern, Monterey, San Benito, San Joaquin and Santa Clara Counties.

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VARIETIES

Few public onion breeding programs exist in the United States (none in California), but a large number of private seed companies are involved in onion variety development. Because of this, a large number of varieties, most of which are hybrids, are available for any given area.

Onion varieties are generally classified according to day length (short, intermediate, and long), market use (green, fresh bulb, dehydrator bulb), and bulb color (within the fresh market class: yellow, brown, red, and white). A continuum of day length varieties has been developed, sometimes making the distinction between the different day length classes difficult. Adjustments can also be achieved by varying planting dates and using transplants instead of direct seeding.

Short-day fresh-market bulbs are usually Granex, Grano, or combination Granex-Grano types. Granex varieties are flat to thick-flat in shape; Grano types are large globe or top-shaped. Some varieties that are grown include Texas Early Grano 502, Don Victor, Matahari, Red Rock, Red Grano, Kristal, Solano and many others. Most fresh-market short-day varieties are relatively low in soluble solids (5 to 7%) and pyruvic acid (2 to 6 moles/kg), with a relatively high sugar to pyruvate ratio. This makes them sweeter than other varieties. Other factors, such as sulfur content in the soil and temperature, influence the level of sweetness as well.

Short-day onions are usually preferred by the onion ring industry because varieties have been developed with a single center (growing point) and numerous, thick fleshy rings; however, more intermediate and long-day varieties are also being developed with a high percentage of single centers. Short-day varieties are considered to be a nonstorage or short-storage crop because they are soft, easily bruised or cut, and have thick necks and thin outer scales. They are harvested slightly immature to meet market demands. When allowed to mature fully, and if harvested carefully, short-day varieties maintain good quality for several weeks, and even months.

Intermediate-day varieties are frequently selections or derivatives from Sweet Spanish types (which may also be long-day). These are usually globe-shaped but may be flattened and must have some resistance to bolting since they grow through winter. They include Stockton Red Globe, Early Red Burger, Cimarron, Caballero, Red River, Rumba and many others. Intermediate-day varieties are also intermediate in solids, pyruvic acid (pungency), and storability.

Few long-day varieties are produced for the fresh market in California. This is because onion growers in the northern region of the United States can produce and store fresh bulbs at a much lower cost. However, the acreage of long-day storage varieties grown in the San Joaquin Valley has increased in recent years, and the acreage in the Antelope Valley (in the higher elevations of Los Angeles County) has remained steady. The potential for production and storage in the northern mountain valleys of California has not been fully developed. Numerous Sweet Spanish and Fiesta types (Sweet Spanish by Yellow Globe cross) have been adapted for California production between 37°N and 42°N latitude. Color types of red, white, and yellow are grown. Some long-day bulb varieties with intermediate to good storage periods are Frontier, Tamara, Sedona, Norstar, Vaquero, Granero, Red Wing, Mercury and many others. Long-day varieties are harvested in late summer and early fall. Because half of all onions grown in the United States are harvested during this same period, long-day varieties must withstand some storage in order to be marketable. In general, successful varieties have very firm bulbs, more and tighter outer scales, thinner necks, solids content of 8 to 12 percent, and pyruvic acid levels of 10 to 20 moles/kg.

PLANTING

Most commercial acreage is direct seeded, but transplants are used in some fall-planted fields for an earlier harvest of short-day (particularly in regions north of the southern deserts) and intermediate-day (in the San Joaquin Valley) varieties, and to achieve uniform, jumbo-sized bulbs.

Onions are most commonly grown in multiple rows on raised beds 40 to 42 inches (102 to 107 cm) wide, but some production systems use 36-inch (91-cm) beds or wide beds of 60 to 80 inches (152 to 203 cm). Distribution of rows across the bed depends on the irrigation method and planter. With drip or sprinkler irrigation, rows are spaced equidistantly across the bed at approximately 4-inch (10-cm) intervals. When furrow irrigation is used, the center of the bed is left empty for salt accumulation, with 2 or 3 rows planted on either side of the center of the bed. Most seeding is done with precision air planters, although some mechanical plate planters are used, especially in the southern desert.

Onions are planted to a stand at 3 to 4 inch (7.6 to 10.2 cm) spacing between seeds using 180,000 to 209,000 seeds/acre (445,000 to 516,000 seeds/ha). Good singulation is critical to avoid doubles. Both pelleted and raw seed are used; primed seed is used to facilitate rapid emergence in cool soils. The shallow planting of onion seed—at approximately ½ inch (12.5 mm)—requires a soil surface that is well prepared and must be kept moist until germination. More shallow plantings may increase the tendency for flatter bulbs, and deeper planting may result in lower germination and rates of emergence, as well as deeper-shaped bulbs.

Onion seed is susceptible to loss of vigor from high temperature and humidity; germination tests are critical. The storage life of opened seed containers can be shortened very rapidly if not immediately placed in an environment low in temperature and humidity. Seeding rates should be adjusted for lower germination. Fresh-market onion seed is planted 2 to 3 pounds per acre (2.4 to 3.6 kg/ha).

SOILS

Onions will grow in a wide range of soil types: sand, loam, clay, and organic-peat. Onions are shallow rooted and need a friable soil that retains moisture well. Excessively dense clay soils interfere with root growth and frequently result in a serious clod problem at harvest. Sandy soils require more frequent irrigation. Seed germination and seedling establishment require a seedbed that is uniform, clod-free, firm, and several inches deep. Compared with planting on flat or small ridges, raised beds provide better drainage and an area for salt accumulation away from the root zone.

Onions are sensitive to salinity, primarily at the stages of germination and emergence. Once plants are established, higher levels of salinity are tolerated. Yield reductions may occur in soils with an electrical conductivity greater than 1.2 dS/m (mmho/cm) or irrigated with water with an electrical conductivity greater than 0.8 dS/m. A 50 percent yield reduction may occur at soil electrical conductivity levels of 4 to 5 dS/m. Onions are sensitive to boron in concentrations greater than 0.5 mg/L in irrigation water.

IRRIGATION

Overhead sprinklers are typically used for germination and stand establishment. Onion seed must not dry out during germination, and the soil surface should not be allowed to crust during seedling emergence, which may last 10 to 20 days following the initial irrigation. After emergence, the crop is usually irrigated by furrow or drip. Drip tape is typically placed on the bed surface when the plants are 6 to 8 inches in height (2 to 2.5 months after planting). Some growers bury the tape an inch below the surface before planting so the crop can be irrigated earlier with the drip system than when the tape is placed on the bed surface.

Onions require frequent irrigation throughout the season for several reasons. Ninety percent of the roots are in the upper 12 inches (30 cm) of the soil, so very little water is extracted from a soil depth of more than 24 inches (61 cm). Moisture is required near the surface of the soil to stimulate new root growth because onion roots are mostly nonbranching, and all roots originate at the stem, or basal plate, of the plant. Rates of transpiration, photosynthesis, and growth are lowered by even mild water stress. Periods of water stress may reduce bulb size and may also cause doubles and splitting; water-stressed plants are usually higher in pungency.

The amount and frequency of irrigations depend on the method, soil type, weather conditions, and development stage of the crop. After emergence, when plants are small, water needs are low, so the irrigation interval with overhead sprinklers may range between 7 to 10 days. As plants begin to bulb water use increases and irrigations become more frequent to maintain uniform soil moisture in the beds. Under drip irrigation, onions may be irrigated every 2 to 4 days, and under furrow irrigation, about every 5 to 6 days. Water is cut off when the bulbs have reached maturity. Usually a minimum of 1 month without water is needed for the tops to dry down before harvest. An onion crop typically uses 20 to 30 inches (50 to 76 cm) of water to meet evapotranspiration requirements. Most growers apply 30 to 48 inches (76 to 122 cm) to achieve maximum yields.

The combination of soil moisture monitoring and weather-based irrigation scheduling can be used to determine water needs of onions. For optimal plant growth on most soil types, irrigate to maintain the soil water tension less than 30 centibars (kPa) in the upper 12 inches (30 cm) of the soil. Keeping soil moisture too high (< 10 cbars) has been shown to reduce the storage life of bulbs. Water use is highest when the crop reaches full canopy cover. Water extraction of onions can be estimated using reference evapotranspiration data adjusted with a crop coefficient, which is closely related to the percentage of ground covered by the leaf canopy. At a maximum canopy cover of 85 percent, the crop coefficient is nearly 1.0. Because evaporation represents a majority of the water loss during the early stages of growth, a crop coefficient between 0.3 and 0.5 should be used for overhead sprinklers, depending on the irrigation frequency, until the leaves shade more than 30 percent of the ground. Maximum onion yields are reached with applied water from 100 to 150 percent of crop ET. The California Irrigation Management Information System (CIMIS) coordinated by the California Department of Water Resources provides daily estimates of reference evapotranspiration for most production regions of California (see http://wwwcimis.water.ca.gov).

FERTILIZATION

Because onions are shallow rooted and usually planted in cool soils, they are responsive to fertilization. Soil analyses are the best indicators

for phosphorus (P) and potassium (K). Soils with bicarbonate extractable phosphorus greater than 30 ppm should require a preplant application of no more than 50 pounds of P_2O_5 per acre, while soils at less than 10 ppm phosphorus may require up to 200 pounds of P_2O_5 per acre. With adequate preplant application, in-season phosphorus application is seldom warranted. Soils in excess of 150 ppm ammonium-acetate-exchangeable potassium are unlikely to respond to potassium fertilization, while up to 150 pounds of K_2O per acre may be required to ensure adequate potassium supply in soils at less than 100 ppm potassium. Most California soils have adequate availability of all micronutrients; where micronutrient deficiency occurs, zinc is often the most limiting nutrient.

Nitrogen (N) requirements vary depending on many factors, including the nitrogen-supplying capacity of the soil, irrigation efficiency, and the amount of leaching from rainfall. If irrigation is efficiently managed a seasonal total of 250 pounds of nitrogen per acre should be adequate to maximize yield under most field conditions, less if the field has significant residual nitrate-nitrogen concentration. Higher seasonal nitrogen rates may be justified in fields receiving significant rainfall, or in which high irrigation efficiency cannot be achieved. Nitrogen fertilizer should be delivered in multiple applications through the season, with no more than 20 to 30 percent of the seasonal total applied preplant.

INTEGRATED PEST MANAGEMENT

UC IPM Pest Management Guidelines for onions are available for weed, insect, disease, and nematode pests. Sanitation, crop rotation, resistant varieties, and frequent monitoring are essential in the prevention and control of onion pests. Visit the UC IPM Web site at http://www.ipm.ucdavis.edu.

Weed management. Onions compete poorly with weeds because they initially grow slowly and the crop canopy does not provide complete ground cover. In addition, the long growing season allows for successive flushes of winter and summer weeds. There are a number of herbicides registered for use on onions; weed control in conventionally produced onions consists of applying preemergence followed by postemergence herbicides. Organic producers rely on cultural practices such as rotating onion plantings into fields with low weed pressure and the use of preirrigation followed by shallow tillage to kill an initial flush of weeds. Under both production systems, hand-weeding is required to control weeds later in the growth cycle. However, the cost of hand-weeding can vary widely, depending on the effectiveness of early season weed control efforts.

Insect identification and management. Thrips (western flower and onion) and maggots (seed corn and onion) are the most frequent serious insect problems for onions, but bulb mites, wheat curl mite, leafminers, and armyworms are occasionally serious pests.

Bulb mite (*Rhizoglyphus* spp.) is most damaging when plant growth is slowed by cool, wet weather. The mites cut off the radicle of germinating seed before the plant becomes established or penetrate the outer layer of tissue and allowing rotting organisms to gain entry to bulbs. Decaying cole crops or other crop residues cause a rapid buildup of mites. Allowing complete decomposition of organic matter causes the mite population to crash, which is the best management option.

Maggots (*Delia* spp.), similar to bulb mites, are favored by cool, moist soils with high levels of nondecomposed organic matter. Seed corn maggot larvae attack germinating seedlings, feeding on the developing roots and epicotyl. Onion maggots also damage seedlings but continue feeding on the expanding bulb, causing bulbs to be lost at harvest or rot during storage. Allow complete decomposition of organic matter prior to planting or transplanting, or if this is not possible, a soil applied insecticide may be used.

Thrips (*Thrips* and *Frankliniella* spp.) can reduce yield and storage quality of onions. Thrips are most damaging when they feed during the early bulbing stage of plant development. Sprinkler irrigation can help reduce thrips numbers, but for high populations foliar insecticide applications are required to prevent injury. Onion thrips *(Thrips tabaci)* adults can transmit *Iris yellow spot virus* (IYSV), but the virus is acquired during the larval stage. Insecticide treatments do not completely prevent IYSV transmission.

Disease identification and management. Downy mildew *(Peronospora destructor)* and purple blotch *(Stemphylium vesicarium,* most common in California, and *Alternaria porri)* are the most serious foliar diseases. Bacterial rots (*Pseudomonas* and *Erwinia* spp.) start as foliar diseases before spreading to the bulb. They are a particular threat to plants grown under sprinkler irrigation throughout the season. Bacterial contamination is intolerable in processing plants and should be kept to a minimum. Pink root *(Phoma terrestris)*, white rot *(Sclerotium cepivorum* Berk.), Fusarium basal rot *(F. oxysporum* f.sp. *cepae)*, and bacterial rots (*Pseudomonas* and *Erwinia* spp.) are common diseases during production. White rot incidence in the San Joaquin Valley has increased dramatically in the last 10 years, with over 13,000 acres (5,260 ha) currently reported as infested. The virus transmitted by onion thrips (IYSV) causes necrotic lesions on scrapes and leaves and if severe can cause a reduction in bulb size. Black mold *(Aspergillus niger)*, neck rot *(Botrytis allii),* and blue

mold *(Penicillium hirsutum)* are the most common harvest and postharvest diseases. In California Xanthomonas leaf blight (*Xanthomonas axonopodis* pv. *Allii*) occurs only in the Antelope Valley and can be a severe problem in some years.

Nematode identification and management. Stem and bulb nematode *(Ditylenchus dipsaci)* and root-knot nematodes (*Meloidogyne* spp.) can be a problem in California onion production, but this does not occur frequently.

HARVESTING AND HANDLING

When the necks weaken and the tops begin to fall over, onions are mature and ready for harvest. Bulbs destined for storage must be mature before undercutting and harvest. Marketing considerations of short- and intermediate-day onions frequently result in harvest when only 20 to 50 percent of the bulbs are mature. These bulbs must be marketed immediately as immature bulbs will regrow tops.

Irrigation management before harvest is critical. Water use demand remains high until maturity begins, then decreases rapidly. Careful evaluation must be made to properly time the last irrigation. Stopping irrigation too soon reduces yield; irrigating too late, or applying too much water late in the season, can cause splitting, delay maturity, and increase the incidence of decay. The last irrigation is best applied when 10 to 50 percent of the tops are over.

Onions are harvested by hand or, for lightly processed onions (i.e. froze products), machine. For hand-harvest, onions are undercut with a rod weeder, and the onions are pulled, clipped, and placed into burlap sacks and left in the field to cure for 3 days to 2 weeks. This process allows onions to dry and form a protective outer covering on the bulbs. The onions are then lifted and transported to a packing shed or field packer. Packing involves sorting into groups according to bulb diameter: colossal (> 4 in, or 10 cm), jumbo (3 to 4 in, or 7.5 to 10 cm), medium (2 to 3 in, or 5 to 7.5 cm), repacks (1.5 to 2 in, or 4 to 5 cm), and boilers (< 1.5 in, or 4 cm). Packing for market is primarily accomplished in 50-pound mesh bags or 50-pound cardboard boxes. Mechanized harvest involves topping the onions with a flail mower followed by lifting and windrowing to allow onions to cure. The onions are then lifted, placed in bins, and transported to the processing facility.

POSTHARVEST HANDLING AND STORAGE

Bulbs that are marketed directly from the field during spring and summer are stacked on pallets in the shade in a manner that allows air movement through the stacks. The shelf life of bulbs harvested before maturity is only 4 to 6 weeks. Mature bulbs can be stored for a considerably longer period at ambient temperatures.

Optimal storage temperature and relative humidity for onions is near 32ºF (0ºC) and 60 to 70 percent humidity. Respiration increases logarithmically above 32ºF (0ºC), as does growth of most disease organisms. Roots sprout and mold growth increases at high humidity. Air movement is essential to maintain uniform temperature and humidity conditions. Skin color and retention are improved at higher humidity, but levels should not be raised above 70 percent.

Black mold *(Aspergillus niger)* is a common postharvest disease that is usually triggered by moisture, such as a light rain shower or dew at or near harvest. The disease appears several days later. *A. niger* does not grow at temperatures below 55º to 60ºF (12.8º to 15.6ºC). Gray mold (*Botrytis* spp.) can start in the neck when bulbs are incompletely dried and cured then engulf the entire bulb, originating in the interior or exterior. Blue mold (*Penicillium* spp.) is enhanced by cool temperatures. Prevention is the only effective management scheme against the above diseases. Sanitation in and around storage facilities, proper curing, low temperature and humidity, and adequate air movement are essential.

MARKETING

Harvest begins in southern areas of the United States and moves northward. Market prices are highly dependent on the supply and quality of product from the preceding harvested areas, including harvests in Georgia and earlier spring harvests in southern Texas.

Transplanted short- or intermediate-day varieties are harvested in the San Joaquin Valley in late May and June. Direct-seeded fields are harvested in July, August, and September. In July and August, early harvest begins in the northern United States. Very few fresh-market bulbs are produced in northern California because production costs are higher and markets and transportation systems have not been developed.

The largest acreage of fresh onions is found in Imperial, Fresno, and San Joaquin Counties. In recent years, increasing amounts of summer-harvested bulbs from the San Joaquin Valley are stored in refrigeration for marketing through the fall and early winter. Red, yellow, and white varieties are produced and marketed this way.

Lightly processed onions are primarily intermediate, mild types with most buyers from the institutional and food service industries. The majority of the demand for fresh onion rings continues to be for whole, unpeeled bulbs with single centers.

FOR FURTHER INFORMATION

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