VEGETABLE RESEARCH AND INFORMATION CENTER

Vegetable Production Series

SPINACH PRODUCTION IN CALIFORNIA

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PRODUCTION AREAS AND SEASONS

California produces spinach (*Spinacia oleracea*) in four areas: the southern desert valleys (Imperial and Riverside Counties); the southern coast (Santa Barbara and Ventura Counties); the central coast (Monterey, San Benito, Santa Clara, and Santa Cruz Counties); and the central San Joaquin Valley (Stanislaus and Tulare Counties). Almost half of California's spinach acreage and production is in Monterey County. The southern coast and San Joaquin Valley each produces about one-fourth of California's spinach, followed by Coachella Valley in Riverside County.

Spinach is produced all year in the coastal valleys, with a slight dip in December in both planting and harvest. In Coachella Valley planting occurs from October through December for harvest from November through March. In the San Joaquin Valley planting starts in late October and continues through January for harvest from February through April.

SPINACH ACREAGE AND VALUE

Year	Acreage	Average yield (*tons/acre*)	Gross value / acre
1994	11,451	10.5	$5,681
1993	11,057	10.2	$5,276
1992	11,622	8.7	$4,688

Source: *Annual California County Agricultural Commissioners' Report Data* (Sacramento: California Department of Food and Agriculture, 1992–1995).

CLIMATIC REQUIREMENTS

Spinach is a quick-maturing, cool-season hardy vegetable crop. Seed germinate at 35° to 85°F (2° to 30°C), but 45° to 75°F (7° to 24°C) is optimum. Spinach will grow from 40° to 75°F (5° to 24°C) but growth is most rapid at 60° to 65°F (15° to 18°C). Spinach can withstand 15° to 20°F (–9° to –6°C) without great injury. Freezing weather harms small seedlings and plants approaching maturity more than at other stages, when the crop will tolerate subfreezing temperatures for weeks.

Spinach produces a rosette of fleshy leaves that may be wrinkled or smooth. Leaves are oval, rounded, or triangular and are borne on a short stem. As the crop matures the stem elongates, producing a seedstalk with narrow, pointed leaves. Premature seedstalk formation (bolting) is caused by late-season high temperatures and long days, reducing market value.

VARIETIES

Spinach is classified according to leaf type: savoy (wrinkled), semi-savoy, and smooth (flat). Savoy types are primarily used for fresh market purposes, while smooth types are preferable for processing. Semi-savoy types are grown for either market. Spinach is also classified according to seed type: prickly or smooth. Most commercial varieties are now smooth-seeded, which are much easier to handle and plant accurately.

All spinach varieties commercially grown in California are hybrids, primarily because disease and bolting resistance have been bred into them. Downy mildew is an economically important foliar disease of spinach for which single-gene resistance is incorporated as new races of the pathogen develop. To keep bolting at a minimum, physiological stress such as increased day length, high temperatures, close plant spacings, and inadequate fertility and irrigation must be minimized. Processors sometimes breed their own varieties for their contracted growers.

Popular varieties in California include, for the fresh market, Bossanova (DM 1234) and St. Helens (DM 123); for the processing market, Bolero (DM 1234), Nordic (DM 1234), and Polka (DM 123); and for either market, Polka and Shasta (DM 123). Numbers in parentheses after the variety name indicate races of downy mildew (DM) fungus to which the variety is resistant.

PLANTING

Spinach is typically grown in two or four rows on beds 38 to 40 inches (95–100 cm) wide. It is also grown on beds 30 and 60 inches (75 and 150 cm) wide. All spinach is direct seeded; seeding rates depend on row configu-

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ration, market destination, and, to a lesser extent, type of seed. Seeding rates range from 9 to 25 pounds per acre (10–28 kg/ha). Coastal producers sow as many as one million seed per acre (25 lb [28 kg]) in a four- or six-row configuration for fresh market bunches, whereas a two-row configuration using 15 pounds per acre (17 kg/ha) provides a higher quality pack for some interior valley areas. Spinach seed is planted ½ to ¾ inch (1.2–1.9 cm) deep, depending on the method of planting and soil conditions.

Seeding rates higher by as much as 50 percent are used for fresh market plantings because the crop is harvested at a considerably younger growth stage, when leaves are small and upright. A typical fresh market spinach crop can be grown in 30 to 55 days. The same variety grown for a processor takes 70 to 120 days, to allow more time to develop greater plant size and large, smooth leaves.

SOILS

A variety of soils are used for spinach production, but in most regions sandy loam soils are preferred. In the inland valleys, soils with considerable sand are desirable for winter and early spring crops because they are warmer. Harvesting is often possible on sandy ground during rainy periods when it is impossible to work on loamy clay soils. Heavier soils can be quite productive if they are well drained and irrigated with care. Spinach is particularly sensitive to saturated soil conditions. It is quite salt tolerant relative to other vegetable crops; a 25 percent yield reduction can be expected with a soil salinity of 7 ECe (dsm^{-1} at 25°C).

IRRIGATION

Almost all spinach fields in California are sprinkler irrigated to germinate the seed. The first irrigation will germinate the crop, but several short sprinkler applications are often necessary to prevent soil crusting. Once a uniform stand is established, most growers switch to furrow irrigation; some grow the entire crop with sprinklers. Continued use of sprinkler irrigation favors infection and spread of leaf spotting diseases.

Spinach has a relatively shallow root system and thrives on frequent shallow irrigations to retain a uniform moist soil for maximum leaf production. Between emergence and harvest, one to three irrigations are usually required totaling approximately 6 to 12 acre-inches (620–1,240 cu. m) for a fresh market crop and 18 to 24 acre-inches (1,860–2,480 cu. m) for a processing crop. The amount of irrigation also depends on soil and climate. Care must be taken to avoid saturated field conditions to prevent rotting of the lower leaves and crowns.

FERTILIZATION

Spinach is moderately fertilized. The rate of fertilizer should be chosen with consideration of soil type, recent cropping history, and soil test results, which help indicate phosphorus (P) and potassium (K) fertilizer requirements. The test for bicarbanate extractable phosphorus estimates how much P is available to plants. Soils above 30 ppm generally do not require additional P; however, when planting in cold soils, P is less available to plants so applications of P may be necessary. Soils with ammonium acetate extractable K greater than 150 ppm generally do not require additional K. Preplant P application ranges from 50 to 100 pounds of P_2O_5 per acre (56–112 kg/ha). Some growers broadcast it, then list the beds; others apply it in a band 2 to 3 inches (5–7.5 cm) to the side and below the seed row after beds are listed but prior to planting.

Nitrogen (N) amounts range from 80 to 200 pounds of N per acre (90–224 kg/ha), depending on the length of the growing season and market destination. A short-season, fresh market spinach crop requires 80 to 100 pounds of N per acre (90–112 kg/ha), while almost twice as much is needed by a crop of processing spinach. Approximately 50 pounds per acre (56 kg/ha) are applied preplant followed by one to three sidedress or water-run applications. Sometimes AN-20 (ammonium nitrate, 20-0-0) or UAN-32 (urea–ammonium nitrate, 32-0-0) is sprayed over the shielded plant row for weed control and to supply N to the crop.

Petiole sampling midway through the season can help determine if the fertilizer program is adequate. When dry tissue analysis reveals less than 4,000 ppm NO_3-N, 2,000 ppm PO_4-P, or 2 percent K, an application of fertilizer would likely improve quality and yield.

INTEGRATED PEST MANAGEMENT

Integrated pest management (IPM) information is continually being developed for weed, insect, and disease problems in California spinach. Cultural control methods such as mechanical cultivation, field sanitation, good drainage, and irrigation management to avoid excessively wet soils are important components of IPM that help minimize the use of chemical controls. Herbicides, insecticides, and fungicides should always be used in compliance with label instructions. Contact the UC Davis IPM World Wide Web site at http://www.ipm.ucdavis.edu or your local Farm Advisor for current pest management guidelines.

Weed management. Weed management is essential in spinach production, especially during the seedling stage when dense weed populations reduce spinach seedling vigor and uniformity. Timely cultivations in the early-growth period are required to reduce weed populations, since opportunities for mechanical cultivation decrease as the dense planting rapidly develops a canopy. If present when the spinach matures, weeds will interfere with harvest. This is especially true with stinging nettle (*Urtica urens*), one of the most troublesome weeds in spinach. Other cool-season weeds that predominate in spinach fields include annual bluegrass (*Poa annua*), sowthistle (*Sonchus oleraceus*), prickly let-

tuce (*Lactuca serriola*), little mallow (*Malva parviflora*), and mustards such as London rocket (*Sisymbrium irio*) and shepherd's purse (*Capsella bursa-pastoris*).

Herbicide options are very few due to cancellations of registrations in the last 10 years. Nearly all fields are treated with preplant and/or preemergence herbicides. Consult your local Farm Advisor for advice on specific weed problems.

In some areas AN-20 or UAN-32 is surface-banded over the shielded plant row as a postemergence herbicide to burn back susceptible weeds and simultaneously supply N to the crop. It is crucial to time the application properly—spinach must be young with less than six true leaves—and avoid spraying the growing point or emerging new spinach leaves or crop damage may occur.

Disease identification and management. An integrated disease management approach, including the use of disease-resistant cultivars, crop rotation, careful irrigation, fertility management, and fungicides, is often necessary to produce a high-quality product.

Damping-off disease, caused by the complex of *Fusarium*, *Pythium*, and *Rhizoctonia* fungi, is problematic in spinach production areas throughout the world. Severity is influenced by cultivar, soil temperature, soil moisture, and disease pressure. Severe damping-off of spinach is associated with warm, wet soils with a history of frequent spinach production. Management practices typically include the use of a seed-treatment fungicide.

Several diseases attack the marketable leaves of spinach. Downy mildew (or blue mold) caused by *Peronospora farinosa* f. sp. *spinaciae* is probably the most widespread and potentially destructive disease of spinach worldwide. Initial symptoms are slightly yellow, irregular, chlorotic lesions on leaves, which frequently expand and coalesce. Heavily infected leaves appear curled and distorted. The characteristic purple sporulation is often observed on the lower sides of lesions. Under conditions of prolonged leaf wetness and cool temperatures, epidemics can progress very rapidly and an entire crop can be lost in a short period of time. Historically, downy mildew has been controlled by planting cultivars with single-gene resistance to a given race. However, when new races of the downy mildew pathogen appear, it may be several years before a new commercial cultivar with single-gene resistance becomes available. Consequently, other management practices become vital, including the use of fungicides.

Several fungi cause leaf spot diseases on spinach. Anthracnose, caused by *Colletotrichum dematium* f. sp. *spinaciae*, can be particularly damaging to spinach foliage. Initial symptoms are small circular, water-soaked lesions on both young and old leaves. Lesions often enlarge and become chlorotic or necrotic and leaves look entirely blighted as lesions coalesce. Anthracnose epidemics are sporadic and are favored by very wet conditions. Dense plantings, poor air circulation, and low plant fertility increase the severity of epidemics. Management practices such as irrigation and fertilization reduce the severity of anthracnose epidemics. Several copper fungicides have been used to slow anthracnose epidemics, but they generally have been ineffective, particularly under very wet conditions. In California the only other leaf spot pathogen of concern is *Heterosporium* sp., which causes small, circular yellow lesions. This disease is usually only problematic during wet springs.

Cucumber mosaic virus (CMV), beet western yellows virus (BWYV), and beet curly top virus (BCTV) are three of the most common viral diseases damaging spinach leaves. On spinach CMV causes spinach blight. Symptoms vary greatly according to cultivar, plant age, temperature, and virus strain. CMV on spinach is vectored by aphids in a nonpersistent manner. BWYV has a very broad host range that includes several important vegetable crops such as broccoli, cauliflower, lettuce, pea, potato, and radish. Many weed hosts, particularly weeds in the mustard family, can serve as reservoirs of inoculum. This virus is vectored by aphids in a persistent or circulative manner and can persist in aphids for relatively long periods (4 to 6 weeks). BCTV on spinach can be very destructive. Symptoms appear 3 to 4 weeks after infection and plants usually die a few weeks after symptoms appear. BCTV can be particularly severe in spinach fields with poor stands or low plant populations. Weeds that may serve as vector reservoirs for the virus, which is transmitted by leafhoppers, should be controlled.

Insect and mite identification and control. Spinach has relatively few insect pests. Careful field inspections are necessary, however, since key pests can cause economic failure in a short time. Consult your Farm Advisor with a specific problem, as chemicals that may legally be used to control pests change frequently.

Leafminers are an increasingly serious problem in the production of spinach in the coastal regions. Three species predominate as pests: serpentine leafminer (*Liriomyza trifolii*), vegetable leafminer (*L. sativae*), and pea leafminer (*L. huidobrensis*). Damage by leafminers results when female flies puncture leaves to feed on plant sap and lay eggs in the leaf tissue. Adult "stings" appear as holes or bumps on the spinach leaves. Adult leafminers have such a preference for cotyledons that seedling growth may be stunted. After eggs hatch, larvae feed between upper and lower leaf surfaces making distinctive winding, whitish tunnels or mines. Excessive mining renders leaves unmarketable, reduces photosynthetic capacity, and provides easy access for disease organisms.

Natural enemies, especially parasitic wasps in the genus *Diglyphus*, can reduce leafminer populations quite effectively; however, when insecticides are applied for the leafminer adult or other pests, parasites are also killed. Leafminer control with insecticides is

grouped into two types: adult control with contact materials and larval control with systemic materials. Larval control is less susceptible to reinfestation and more persistent. Cultural practices such as postharvest disking of the field destroy pupae and reduce migration of adult flies into a susceptible field, as does keeping a distance between fields.

Several species of aphids are found on spinach in California, but the green peach aphid (*Myzus persicae*) is probably the most common. Aphid populations can build up in spinach to densities of several thousand per plant. These pests stunt plants and reduce yield through plant sap removal; transmit viral diseases, especially cucumber mosaic virus; and contaminate spinach produce, particularly fresh market spinach, with aphid honeydew, sooty mold, and debris. Regular monitoring of spinach fields is necessary. At certain times of the year parasitic wasps and predators provide natural control of aphids, while at other times aphid populations soar rapidly and contact or systemic insecticides may need to be applied.

Spinach can sometimes be damaged by populations of a bulb mite (*Rhizoglyphus* sp.), commonly called the spinach crown mite. This very tiny pest feeds in the developing leaves and causes distorted growth. The mites are especially difficult to see because of the naturally occurring glandular hairs on developing leaves. Control must occur before the damage is done, making careful monitoring for this pest very important. Damage is usually most severe in the early spring when plant growth is slow. Spinach planted in fields with recently disked crop residue or weeds is most susceptible.

Abiotic problems. Tipburn is a physiological disorder that causes the tips of spinach leaves to turn brown and wither. Affected leaves are unmarketable and may also be attacked by secondary rot organisms. Tipburn is caused by an imbalance of available calcium in the plant. This condition is usually induced by fast plant growth, warm temperatures, and perhaps high N levels.

HARVEST

Spinach is grown for both fresh and processed markets, and market price sometimes determines how a field of spinach is harvested. Fresh market spinach is field packed. The entire plant is harvested from the time it has five to six leaves to just before seedstalk formation. A plant with a seedstalk is considered unmarketable. Plants are hand cut, tied into bunches of 8 to 12 plants, and packed 24 bunches to a carton with a minimum net weight of 20 pounds (9 kg). Yields, which vary widely depending on planting configuration and density, range from 900 to 1,900 cartons per acre (2,300–4,800 cartons per ha).

Processing spinach is mechanically harvested by cutting above the growing point so that only leaves are harvested and the plant can continue growing for a second harvest. The height of the cutting bar can be adjusted to control the amount of stem and leaf that is cut. The leaves (and a certain percentage of stems) are elevated into a truck trailer or wooden bin and transported to the processing plant for canning or freezing. Typical yields for processing fields range from 7 to 12 tons per acre (16–27 t/ha) at 18 percent stem. Fresh market spinach sold as leaves only is also mechanically harvested. Wooden bins of loose spinach leaves are trucked to a cooler, cooled, then transferred by refrigerator truck to the "lightly process facility" where it is triple-rinsed and packed for market in 6- and 10-ounce (168- and 280-g) plastic bags and larger units for institutional use.

POSTHARVEST HANDLING

Because spinach has a large surface-to-weight ratio and a very high respiration rate, it must be cooled immediately and rapidly to prevent wilting and weight loss. Spinach can be cooled from 66° to 37°F (19° to 3°C) in 10 minutes by vacuum cooling and from 64° to 30°F (18° to –1°C) in 4 hours by forced-air cooling. Spinach stored at 32°F (0°C) at 95 to 100 percent humidity with light mistings will typically have a shelf life of 10 to 14 days. Spinach is sensitive to ethylene and moderately sensitive to freezing injury after harvest.

MARKETING

Approximately 35,000 acres of spinach were grown annually throughout the United States for fresh and processed (frozen and canned) markets with a value of $70 million in the early 1990s. California is the principal spinach-producing state with Texas, New Jersey, Colorado, Maryland, New York, and Ohio also providing supplies.

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