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UC PEER REVIEWED

RACHAEL LONG, UC Cooperative Extension Farm Advisor, Yolo County;

MICHELLE LEINFELDER-MILES, UC Cooperative Extension Farm Advisor, San Joaquin County;

KONRAD MATHESIUS, UC Cooperative Extension Farm Advisor, Yolo County;

KHALED BALI, UC Cooperative Extension Irrigation Water Management Specialist, Kearney Agricultural Research and Extension Center;

SARAH LIGHT, UC Cooperative Extension Farm Advisor, Sutter-Yuba Counties;

MARIANO GALLA, UC Cooperative Extension Farm Advisor, Glenn County;

SHANNON MUELLER, UC Cooperative Extension County Director and Farm Advisor, Fresno County;

ALLAN FULTON, UC Cooperative Extension Farm Advisor, Tehama County;

NICHOLAS CLARK, UC Cooperative Extension Farm Advisor, Tulare County;

ROLAND D. MEYER, UC Cooperative Extension Soils Specialist Emeritus, UC Davis

Garbanzo Bean (Chickpea) Production in California

Garbanzo beans (chickpeas, *Cicer arietinum*) (fig. 1) are an annual grain legume, or "pulse crop," that is used extensively for human consumption. In California, garbanzos are mostly grown for the canning industry as a high-end specialty product, including garnishes for salads. To meet this market demand, canning-quality garbanzo beans must be creamy colored, have a large, uniform seed size, and maintain firmness after canning with no seed splitting or skin peeling. There is also a market for the large-seeded, dry-packaged garbanzo beans. California's Mediterranean climate, with relatively warm, wet winters and hot, dry summers, provides ideal growing conditions for famers to meet this market demand. Most garbanzo beans grown around the world are smaller-seeded varieties that are often milled for flour or used for the increasingly popular hummus food spread.

Figure 1. Garbanzo beans are grown on a bush, with 1 to 2 seeds per pod. Photo: R. Long.

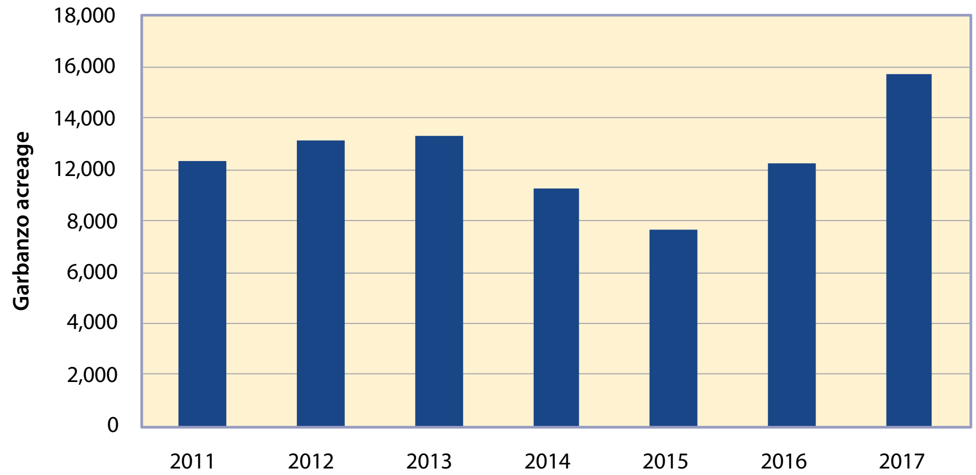

Figure 2. Garbanzo acreage in California, 2011–17. Source: USDA NASS 2018.

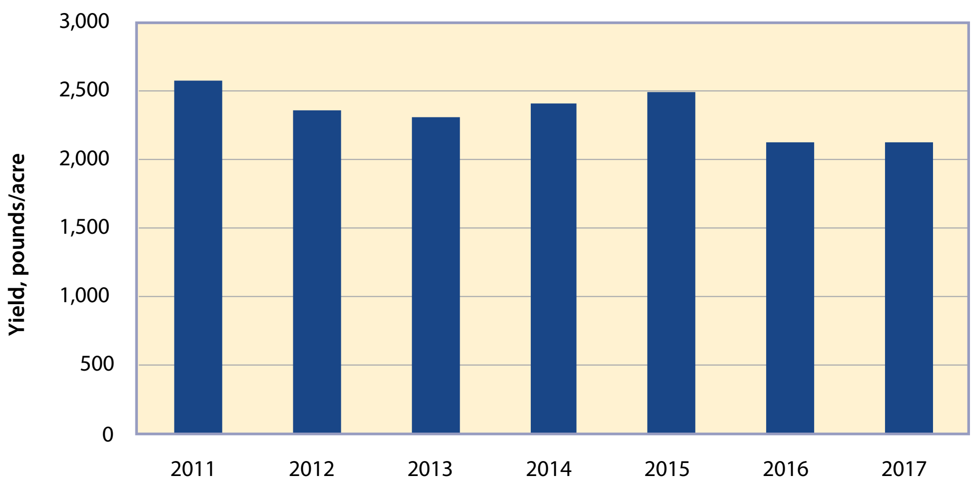

Figure 3. Garbanzo yield (lb/ac) in California, 2011–17. Source: USDA NASS 2018.

Garbanzo beans are an annual, cool-season, winter-planted crop that are mostly grown in the Central Valley. At one time garbanzos were extensively produced on the south-central coast of California, but they have been replaced by higher-value crops, such as grapes, in that region. Garbanzos are favored by farmers in crop rotations because they are a winter crop that is less dependent on irrigation; they offer an alternative competitive crop to winter cereals such as wheat (Light et al. 2018; Clark et al. 2018); and they fix some of their nitrogen needs, requiring fewer fertilizer inputs.

About 10,000 acres of garbanzos are grown per year in California, with yields averaging 2,300 pounds per acre (figs. 2 and 3). Other dry beans grown in California include blackeye peas, or cowpeas, (*Vigna unguiculata*); baby and large limas (*Phaseolus lunatus*); and common beans (*P. vulgaris*) (fig. 4). Garbanzos are an Old World species, originally from the Middle East; blackeyes are from Africa; and common and lima beans are from the Americas. Garbanzos have been farmed since ancient times, though in California, their heritage dates back to the Spanish Mission era. As with all beans, garbanzos are nutritious and healthy, as they are high in fiber, protein, vitamins, and minerals.

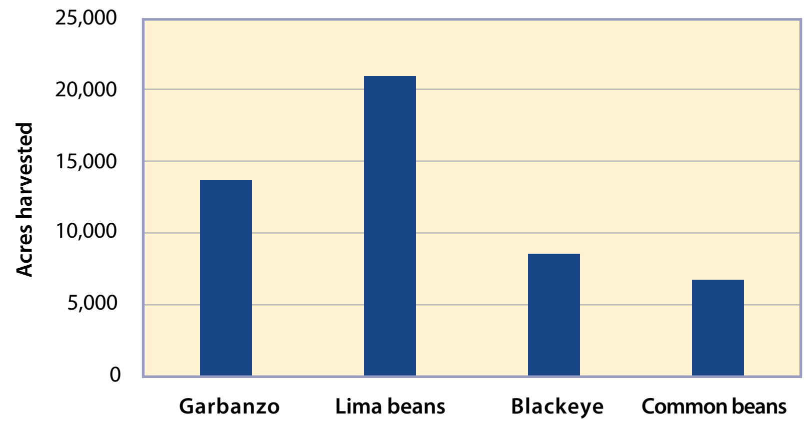

Figure 4. Garbanzo acreage versus blackeyes (cowpeas), lima beans (baby and large), and common dry beans (e.g. kidney, white, cranberry, black, pink) in California, 2017. Source: USDA NASS 2018.

Garbanzos are grown differently in different parts of the state. Bed and row spacing varies; some growers plant dryland, others irrigate with flood or subsurface drip. In addition, inputs vary from low to high, depending on the expectation or goals for the crop. For example, some growers fertilize with nitrogen (N) after planting, and others use only a starter N treatment, depending on potential sources of N from the previous crop. Garbanzos, though a specialty crop, are still a field crop, and economics often plays a role in how the crop is managed. This publication encompasses the various best management production practices for growing high-quality and high-yielding garbanzo beans in California.

VARIETY SELECTION

The two main commercial classes of garbanzo beans are Kabuli and Desi. Kabuli types have large, cream-colored seeds (about 960 to 1,200 per pound) and are used for the canning and dry packaged markets in California. About 1 ounce of Kabuli-type dry garbanzo beans usually turns into 2 ounces of canned cooked garbanzo beans. Desi type seeds are about half the size of Kabuli (about 1,600 per pound), are multicolored, and are generally milled.

Table 1.
Disease resistance and leaf type of Kabuli garbanzo varieties grown in California

Variety	Ascochyta blight resistance[3]	Fusarium wilt resistance[4]	Leaf type[5]
UC Pegasus[1]	M	X	simple
UC Vega[1]	R	X	compound
UC-27[1]	S	R	compound
Sierra[1]	R	X	simple
San Joaquin (LA13)[2, 6]	M	M	compound
Sutter[2]	R	X	compound
Air-Way Farms, AWF[2]	R	X	compound

Key
M = moderate
R = resistant
S = susceptible
X = not screened

Notes:
1. *Public varieties developed through the University of California, Davis, Grain-Legume breeding program. UC Pegasus and UC Vega show improved yields and canning quality over Sierra.*
2. *Commercial (proprietary) variety.*
3. *A. rabiei (asexual spore stage), Didymella rabiei (sexual spore stage).*
4. *F. oxysporum f. sp. ciceris.*
5. *Simple = unifoliate, compound = fern.*
6. *Based on field observations, shows some resistance to Fusarium root rot, F. solani f. sp. pisi.*

Figure 5. Compound (fern-type, left) versus simple (unifoliate, right) leaf structure of garbanzo beans. Photo: Dr. Weidong Chen.

Kabuli garbanzo plants are typically 2 to 3 feet tall; have white, self-pollinating flowers similar to a pea; and produce one to two seeds per pod. The stems, leaves, and seed pods are covered with small, hairlike, glandular structures that secrete malic and oxalic acid, which can cause skin rashes and damage clothing. Some varieties have compound leaves, also called fern types, with eight to twenty leaflets, whereas other types have simple leaves, also called unifoliate (fig. 5).

Kabuli garbanzo varieties grown in California, along with their disease resistance and leaf types, are shown in table 1. UC Pegasus and UC Vega were released in 2017 from UC Davis breeding trials and show improved yields and canning quality compared with Sierra, the standard UC public variety.

SEED SELECTION AND HANDLING

Garbanzo bean planting stock must be selected from lots that meet high performance standards, including seed with no visible defects such as cracks or chips and a germination rate of 85 percent or better. The use of certified seed ensures the best quality seed and minimizes the possibility of introducing plant diseases, weed seeds, varietal mixes, and foreign matter into the field. Saving seed for planting is risky because of seedborne diseases such as Ascochyta and Fusarium wilt that can cause devastating stand and yield losses.

Though garbanzos are tougher than some bean seeds, dry beans overall are inherently fragile and internal damage can easily

Table 2. Soil saturated paste boron and salt tolerance limits of selected field crops

Crop	Boron (B, ppm)	Threshold soil salinity[1]
alfalfa[2]	4–6	>6.0
blackeye peas or cowpeas, Vigna unguiculata	2.5	4.9
common dry beans, Phaseolus vulgaris	0.50–0.75	1.0
garbanzo beans, Cicer arietinum	< 1–2	< 2.5
lima beans, P. lunatus	0.75–1.0	1.5
sunflowers	0.75–1.0	4.8
tomatoes	5.7	2.5
wheat	0.75-1.0	6.0

Notes:

1. *Value is the electrical conductivity of a saturated soil extract, ECe, in dS/m or mmho/cm, and refers to the maximum soil salinity that does not reduce yield below that obtained under nonsaline conditions.*
2. *Recent research indicates a significant range in both B and salinity tolerance and a much higher salinity tolerance for some salt-tolerant alfalfa varieties than reported by Ayers and Westcot 1994.*

Source: Ayers and Westcott 1994; Grieve et al. 2012.

occur, so handle seed bags carefully. Walking on bags, throwing or dropping them, or pouring the seed into hoppers from distances in excess of 24 inches can crack the seed coat and cause internal (cryptic) seed injury. Poorly germinating seed, badly bent or curved seedlings, and missing cotyledons result from seed injury. High-quality seeds germinate rapidly and produce good stands with vigorously growing seedlings.

SITE SELECTION

Garbanzo beans grow best on deep, loamy soils that have light to medium texture with good drainage. They do not tolerate wet soils, so do not plant this crop in low-lying areas where standing water and poor drainage may occur. Garbanzos produced on clay soils must be managed carefully for irrigation and winter drainage to prevent plant dieback. Clay soils tend to remain saturated for long periods, which favors damping off seedling diseases (especially from *Pythium* spp.). Poorly drained and high- or low-pH soils may also be very hostile to beneficial *Rhizobium* spp. bacteria, interfering with nitrogen fixation.

Avoid growing garbanzos in saline, alkaline (pH > 8.0), acidic (pH < 6.0), or high-boron (B) soils. Soils should be tested before planting for salinity and nutrient composition. Soil should be sampled in depth increments of 0 to 6, 6 to 12, and 12 to 24 inches. Take about 12 to 15 cores across the field or from each variable section of a field and composite the sample for analysis. Salinity is usually tested as the electrical conductivity (EC) of the soil saturated paste extract (EC_e). Although garbanzos have some tolerance to B and salinity compared with other crops (table 2), high levels cause stand loss and patchiness in the field. Expect yield declines if B exceeds 2 ppm and salinity exceeds 2.5 dS/m. Site selection is also a good time to test irrigation water for salinity, particularly in regions where groundwater may be high in salt or where surface water may be impacted, such as in the Sacramento–San Joaquin Delta.

If salt builds up in the soil to a level that can impact crop yields, leaching is recommended. Leaching occurs whenever water is applied in excess of crop needs (ET_c), either by winter rainfall or irrigation. Other measures that can move salt out of the root zone include replenishing the soil profile with irrigation water in the fall before planting or irrigating before a storm to leverage the rainfall and optimize winter leaching. If the soil profile is already wet when rain occurs, rainwater can pass through the soil and leach salt, rather than just wet the soil profile.

In addition to soil considerations, avoid planting garbanzo beans next to alfalfa fields. Alfalfa is a host of alfalfa mosaic virus, a serious disease of garbanzos (and lima beans) that is vectored by aphids and can cause significant stand and yield losses. Lastly, there is a very small market for fresh, green garbanzos still in the pod. Theft of plants in the green pod stage can be a problem, so avoid planting garbanzo beans in areas with easy access to production fields.

CROP ROTATION

Crop rotation is required for a healthy garbanzo crop to ensure good weed and disease control. Suggested rotations include wheat, tomato, and sunflower. The main diseases of concern that can be reduced through a 3-year crop rotation include Ascochyta blight and white mold (*Sclerotinia* spp.). For all bean types, avoid planting beans after beans to prevent diseases from building up in the soil and infecting plants.

Grower experience also suggests avoiding planting garbanzos following alfalfa for several reasons. First, some growers have reported stand establishment problems in beans (specifically lima beans and garbanzos) following alfalfa, suggesting that alfalfa may be a host for common pathogens that affect beans. Second, it may be more advantageous to plant a nitrogen (N) requiring crop such as tomato, sunflower, or corn immediately after the alfalfa due to the N benefits of this crop and then rotate into garbanzos after a year or two. For long-term crop rotations on farms, including dry beans helps improve soil tilth, weed control, and may increase soil N fertility (0 to 20 pounds per acre) for following crops.

LAND PREPARATION

Garbanzos are large seeds, so they are less sensitive to seeding depth than smaller-seeded crops. However, they still need a firm seedbed at planting for good soil to seed contact. Primary tillage operations depend on field conditions but generally include disking the previous crop residue, chiseling to a depth of 18 inches to open up compacted soils, finish disking, landplaning, and listing of beds. For semipermanent beds with buried drip, furrows are generally chiseled to 15 inches. Subsequently, a heavy-duty bed tillage implement is used to shallowly chisel, till, and reshape the beds while avoiding disturbing drip tape.

Garbanzos can also be seeded into the previous crop residue using no-till or minimum tillage techniques, helping to reduce field preparation costs and maintain healthy soils. In direct-seed systems where previous crop residue is left on the soil surface, proper residue management and drill selection are essential for obtaining adequate stand establishment. No-till drills work best when the residue is baled and removed or when the residue is chopped into small pieces and spread uniformly on the beds. If disc-type drills are used, uniformly spread the crop residue to avoid leaving thick mats of residue that are difficult to penetrate during planting.

PLANTING DATE, RATE, AND METHOD

Timing

Garbanzo beans generally yield best when planted in December and January in the Central Valley of California, as cooler temperatures help avoid fall and spring aphid flights and the diseases they vector, as well as seed corn maggot infestations. Earlier plantings, such as in November, can be problematic because the plants develop heavy canopies during late winter that favor Ascochyta blight and white mold (*Sclerotinia* spp.) and other foliar diseases. However, sometimes a window of opportunity to plant occurs in February or early March when there is a warm, dry spell as winter weeds are phasing out and before summer weeds germinate. Growers have found that garbanzos planted into moisture at this time have yielded well. With good soil moisture, garbanzos continue to set and produce seed into June, but they senesce when they run out of soil moisture. For December-planted garbanzos, flowering begins in March, and pods develop and fill from mid-April through mid-May.

Rate

A typical planting rate is 80 to 85 pounds of seed per acre on irrigated ground, regardless of row spacing. An ideal plant population is 3 to 4 plants per foot of row (52,000 to 70,000 plants per acre). Some growers plant two rows on a 60-inch bed with either flood irrigation or one buried drip line in the center. Where weeds can be problematic, grower experience indicates that garbanzos have yielded well and outcompeted weeds when 3 rows are planted on 60-inch beds or 2 rows on 40-inch beds. Others plant 4 rows on an 80-inch bed that has two buried drip lines. Sometimes there will be stronger growth from the line of plants in the middle above the buried drip line, but this does not seem to impact garbanzo yield or quality. For dryland production, fields are sometimes seeded about 10 to 15 pounds heavier with a grain drill using closer plant spacing to help with weed control.

Seed Treatments

Planting seed should be treated with fungicides to reduce seedling diseases such as damping off (caused by *Pythium* and *Rhizoctonia*

Figure 6. Root nodules containing nitrogen-fixing bacteria. Photo: UC IPM.

spp.), and Ascochyta blight, which is particularly important when planting into cooler soil during the wintertime.

Depth

Seeding depth should be 1 to 2 inches. However, seeds may be planted 3 to 5 inches deep on loam (not clay), depending on depth to moisture. For subsurface drip-irrigated systems, fields are often planted dry and irrigated with hand-line sprinklers, which also activates soil-applied herbicides. Once the plants are established, subsurface drip irrigation is used to finish the crop.

Inoculants

Garbanzo beans fix nitrogen from the atmosphere in association with the symbiotic bacteria *Rhizobia* that live in nodules in the bean roots. Thus, seed must be inoculated every year at seeding with the proper *Rhizobium* strain of the *Cicer* species to ensure good nodulation for adequate nitrogen fixation and high yields (fig. 6). Granular inoculants can be more effective than peat-based ones because they are usually less affected by fungicide seed treatments. It is important to meter the granular inoculant through seed hoppers and place inoculant in the seed row near and preferably below the seed at planting. This needs to be done as a sidedress operation, separate from the seed, because fungicides can drastically reduce the viability of *Rhizobium* if there is direct contact with the treated seed. Use 5 to 10 pounds of *Rhizobium* granules per acre. Monitor the hoppers so they do not plug up. If the seeds are not inoculated, the plants will be stunted, especially in fields where garbanzos have never been grown before. Inoculants are an inexpensive insurance policy relative to the value of the crop that ensures good nitrogen fixation and plant growth. Store the inoculant under refrigeration and minimize exposure to direct sunlight or high temperature, which kills bacteria.

FERTILIZATION

If soils are deficient in nitrogen (N), phosphorus (P), potassium (K), sulfur (S), or zinc (Zn), garbanzo beans are likely to respond to these fertilizers. Prior to planting, sample the soil at a depth of 0 to 6 inches to determine the likelihood of crop response to P, K, and Zn fertilizer applications as well as to evaluate the soil pH (N will be addressed later). If there were yield differences within the field of the previous crop, sample these areas separately by taking 12 to 15 cores from 0 to 6 inches deep and mixing them together into one sample for that area. The pH of a soil should be from 6.0 to 8.0 for good bean production. A pH less than 5.5 can be corrected with an application of lime. Soil sampling to evaluate salinity and boron (B) concentrations should be collected from depths of 0 to 6, 6 to 12, and 12 to 24 inches if there is reason to suspect toxicity. Knowledge of field history and past nutrient deficiencies (such as S and B) or toxicities (such as salt and B) should be taken into consideration prior to planting garbanzo beans (see table 2).

Organic production of dry bean crops involves adding manures and other slow-nutrient-release materials that must be incorporated into the soil prior to planting. Applying 3 to 5 tons per acre of one of several animal or poultry manures, incorporated several months before planting, often supplies all the nutrient requirements for the bean crop. The economics of applying other acceptable nutrient sources should also be considered. For growers transitioning into organic bean production in soils that require large amounts of P, K, Zn, or possibly lime, it may be more economical to build up the soil fertility by adding synthetic fertilizers prior to the 3-year transition period to organic production.

Nitrogen

Although garbanzo beans fix their own nitrogen (N) from the atmosphere through symbiotic N fixation, they will benefit from modest applications of N fertilizers to ensure high yields. Unlike alfalfa and several other N-fixing crops, *Rhizobium* spp. symbiosis for *Cicer* spp. is generally not able to provide sufficient N to sustain high crop yields, similar to many other bean types (e.g., *Phaseolus* spp.). Periods of soil water saturation or dry, hot weather further reduces N fixation. Therefore, N fertilizers are often needed to ensure that plants receive enough N for rapid growth and high yields.

The main symptom of N deficiency in beans is a uniformly pale green to yellow leaf color, particularly on the older leaves. In addition, plant growth is reduced, flowers may not develop, and pods fill poorly. Conversely, excess or late N applications through drip irrigation may delay flowering, leading to yield and quality reductions. Garbanzo bean seed has a protein content of 24 percent and an N content of 4 percent, so a yield of 2,500 pounds per acre of seed will need at least 100 pounds of N per acre. The vegetative portion of the plant needs an additional 40 pounds or so of N per acre. Of the total 140 pounds per acre of N needed, about 60 percent (50 to 80 percent) of this will likely be supplied by N-fixing nodules on the plant roots, but the rest has to come from other soil sources of N. Therefore, an application of at least 75 pounds of N per acre is typically required for a garbanzo bean crop.

At planting, apply a starter fertilizer (such as 8-24-6 with 1% Zn or similar material) at 10 gallons per acre. The starter fertilizer is particularly important for winter plantings, as soil temperatures are cooler and soil concentrations of available P and Zn are decreased.

Table 3. Phosphorus recommendations for garbanzo beans

Soil test	**Phosphorus (ppm)**				
	Very low	*Low*	*Moderate*	*High*	*Very high*
Bray #1-P	0–5	6–10	11–15	16–20	21+
Olsen HCO3-P	*0–3*	*4–7*	*8–11*	*12–15*	*16+*
Yield goal (lb/ac)	*Application rate (lb P_2O_5/ac)*				
2,000	30	20	10	0	0
2,400	40	30	20	10	0
2,800	50	40	30	20	10

Exercise particular care with starter fertilizer placement to avoid salt damage or ammonia toxicity to the germinating bean seed (do not use urea or diammonium phosphate, either 18-46-0 or 16-48-0). No fertilizer should be placed in direct contact with the seed. As a general rule, monoammonium phosphate (either dry 11-52-0 or liquid 10-34-0) is the preferred base fertilizer and should be placed no closer than about 2 inches to the side and about 2 inches below the bean seed.

Some N will be available in irrigation water, soil, and crop residue and must be accounted for in nutrient management plans required by state regulations. In the fall, along with the annual pump test, take a laboratory analysis of the irrigation water to determine nitrate availability for crop N needs. The pounds of nitrogen per acre-foot of irrigation water is calculated by multiplying the parts per million (ppm) nitrate-N in the irrigation water by 2.72. Know the crop immediately preceding the garbanzo planting, as some crops leave more available N in the soil. For example, tomatoes will likely leave more residual N in the soil than wheat.

For furrow-irrigated fields, assuming low residual N in the soil and irrigation water, incorporate preplant N such as aqua ammonia (20-0-0) at 75 pounds of N per acre in November. The fertilizer should be banded with a shank 8 to 12 inches to the side of the seed row and 4 to 6 inches deep. For subsurface drip irrigation (SDI) fields, inject N fertilizer such as UAN-32 at 75 pounds of N per acre at multiple intervals in increments of about 25 pounds through the drip system during crop growth until bloom time.

Phosphorus

Phosphorus (P) is important for garbanzo bean production, especially with winter planting dates and cooler soil temperatures that reduce P solubility and uptake. Phosphorus promotes the development of extensive root systems and vigorous seedlings. A deficiency is characterized by slow plant growth, thin stems with short internodes, and older leaves that turn yellow and drop prematurely while the new leaves are small and dark green. Flowering may also be delayed, and pod set will often be poor.

If a representative soil test indicates a P deficiency, apply a starter fertilizer containing P at the rate indicated in table 3 as pounds of P_2O_5 per acre. The soil test using the Olsen bicarbonate (HCO_3-P) extract should be used on soils with a pH of 6.5 or greater, while the Bray #1-P extract may be used on soils having a pH less than 6.5. Soil tests showing very low and low extractable P levels would be expected to show a yield response to P fertilization. Crops grown in soils that have test levels in the moderate range are less likely to respond to P fertilizer applications.

Potassium

Potassium (K) deficiency symptoms normally appear in young plants, initially as yellowing around the margins of the older leaves. As the deficiency progresses, leaf margins look scorched and may cup upward, while the yellowing moves toward the center and base of the leaf blade. Growth is reduced, internodes are shortened, and plant stems are weakened, causing them to collapse easily.

Soil test (ammonium acetate exchangeable K) results in the low range indicate that the crop should respond to K fertilization (table 4). Test levels in the medium range indicate that plants are less likely to respond to K applications. If a representative soil test indicates K deficiency, corrections should be made with a starter fertilizer containing K at the rate indicated in table 4 as pounds of K_2O per acre. Few California soils in garbanzo bean growing areas show yield-limiting potassium deficiencies. Sandy soils are likely to be the first to show K fertilizer responses.

Table 4. Potassium recommendations for garbanzo beans

Soil test	Potassium (ppm)		
	Low	*Medium*	*Adequate*
	0–40	41–80	81–120+
Yield goal (lb/ac)	*Application amount (lb K_2O/ac)*		
2,000	20	10	0
2,400	25	15	0
2,800	30	20	0

Sulfur

Sulfur (S) deficiency, though rarely observed in garbanzo beans in California, is characterized by yellowing of younger leaves and stunted growth. It is most common after high rainfall, prolonged periods of wet soil, and cooler soil temperatures from January to March and will generally be observed only once every 5 to 7 years in beans as well as in wheat. Some soil in the Sacramento Valley is likely to show S deficiency, and most irrigation water contains little or no S. Fertilizers such as ammonium sulfate, a common source of S in the past, are no longer being used as commonly as non-S-bearing aqua ammonia and other high-analysis fertilizers, and therefore S deficiencies might occasionally occur.

Broadcast and incorporate elemental S into S-deficient soils at a rate of 50 to 100 pounds of S per acre to provide a correction that will last several years. Elemental S (90 to 95% S) must be applied far enough ahead of planting time to ensure oxidation to sulfate-sulfur, the form used by plants. The time necessary to oxidize elemental S depends on soil temperature and moisture, as well as the size of the S particles applied. Particle size may cause the timeline to change from a few weeks (small particles) to several months (large particles) before the applied elemental S becomes effective. Other materials that provide the readily available sulfate form of S, such as gypsum (calcium sulfate, about 17% S), can also be used. These materials should be applied at a rate that supplies about 25 to 50 pounds of S per acre and should be incorporated into the top 4 to 6 inches in the soil to be most effective.

Zinc

Garbanzo beans often respond to zinc (Zn) fertilizer, especially those that show soil tests below 0.5 ppm as DTPA-extractable Zn. Low Zn availability may occur in soils low in organic matter; calcareous, high pH soils; or on newly leveled land that required extensive cuts and fills. Zinc deficiency causes the youngest leaves to turn pale, followed by necrosis of leaf tissue and stunted growth. The best way to diagnose the Zn status of a field is to perform soil tests before planting.

The most effective application of Zn is a mixed fertilizer containing Zn at 1 to 3 pounds per acre in the starter fertilizer. If the Zn deficiency is discovered in the growing bean crop, Zn sulfate can be applied to established plants as a foliar spray at a concentration of 3 to 4 pounds per 100 gallons of water to correct the deficiency. A spreader-sticker should be added to the solution, and plants should be sprayed "to wet," which usually requires 10 to 40 gallons of the mix per acre, depending on the size of the plants. Chelated Zn may also be used as a foliar-applied correction.

In fields with a severe zinc deficiency, apply a correction that will last for several years by incorporating zinc sulfate (35 to 36% Zn) with a disk into the top 6 inches of soil at a rate of 10 to 20 pounds of Zn per acre if the soil pH is less than 7.0. For soils with a pH greater than 7.0, apply 20 to 30 pounds of Zn per acre. Zinc as zinc sulfate is not mobile in the soil, so it must be placed in the root zone for maximum plant uptake. A Zn correction must be done 2 to 4 months before planting.

Boron

A deficiency of boron (B) in bean production is most likely to occur in sandy soils along the east side of the San Joaquin Valley in California, but it can occur in other locations where soils are inherently low in B and the irrigation water supplies no B. Plant deficiency symptoms include chlorosis and death of young leaves, dead growing points, and distorted blossom development.

Boron toxicity is likely if beans are grown in high-B soils such as those common to the west side of the San Joaquin Valley, part of Yolo County, and several other areas in California. Both soil and irrigation water can be sources of B toxicity for beans. Toxicity symptoms include yellowing of the leaf tips, interveinal chlorosis, and progressive scorching or death of the leaf margins. Garbanzo beans are slightly more tolerant of B than other bean types but are still sensitive compared with other crops (see table 2).

A narrow range exists between deficiency and toxicity for B-sensitive crops such as garbanzos, since too much B reduces yields. Irrigation water should be tested for excessive B levels. While soil samples can be used to assess toxicity, deficiencies are best identified with tissue tests. Average B concentrations in the youngest fully mature leaves can be used to estimate plant B status: deficient (less than 15 ppm), sufficient (20 to 50 ppm), high (50 to 100 ppm), and excessive or toxic (over 100 ppm).

The recommendation for soil application of B in deficient soils is 0.5 to 1 pound per acre, while the suggested rate for foliar application is 0.1 pound of B per acre mixed in 30 gallons of water. The B fertilizer used most frequently is sodium borate, which ranges from 10 to 20 percent B. Solubor is a trade name for a sodium borate that is 20.5 percent B. This fine-granular material is commonly applied as a foliar spray.

IRRIGATION MANAGEMENT

Garbanzos are primarily grown in four climate zones in California: 12, 14, 15, and 16 (see the California Irrigation Management Information System [CIMIS] reference evapotranspiration map, https://cimis.water.ca.gov/App_Themes/images/etozonemap.jpg). The frequency of crop irrigation depends on the time of planting, rainfall, water-holding capacity of the soil, and crop water use (ETc). Garbanzos grown in the south San Joaquin Valley are highly dependent on irrigation, whereas in the Sacramento Valley, much of the water required usually comes from winter rainfall. Garbanzos have a taproot and an extensive root system and can withstand drought conditions by extracting water from deep in the soil profile (see fig. 7). However, they are sensitive to water-logged soil, especially on clay soils, so water must be managed carefully to prevent stand dieback. This can be challenging for a winter-planted crop, especially in wet years in areas with a high water table.

In the Sacramento Valley and Northern San Joaquin Valley, garbanzos are typically planted into moisture from December to February (and sometimes even into early March). They are irrigated via furrow or subsurface drip as needed until May or June, depending on rainfall and available soil moisture. In the San Joaquin Valley, garbanzos are usually planted dry from December to January, sprinkled up with hand-line sprinklers, then irrigated via subsurface drip through early June. Inadequate soil moisture during stand establishment and flowering can lead to stand loss

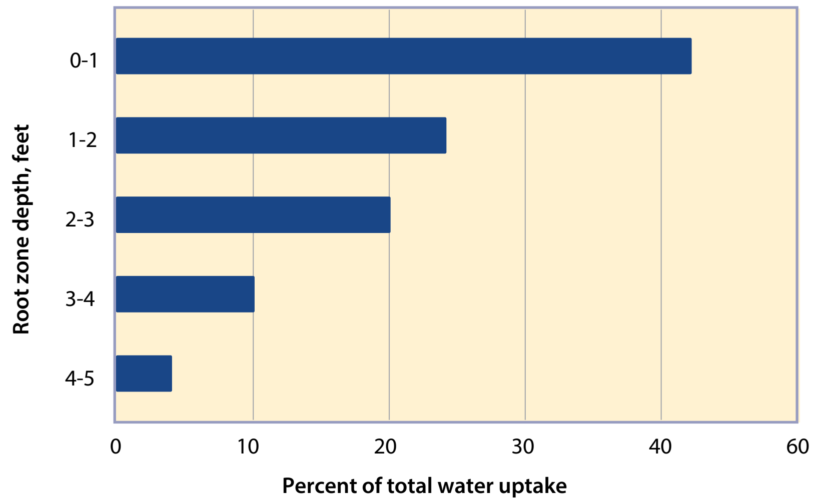

Figure 7. Percentage of total water uptake by root zone depth for garbanzos from winter to early spring. Source: Roberts et al. 1994.

and stress-induced blossom failure and empty seed pods. It is especially important to apply water during the pod development and pod filling stages of growth for maximum yields.

Irrigation Scheduling

Irrigation management of garbanzos requires appropriate irrigation scheduling (determining when and how much to irrigate) and good irrigation management to deliver the desired amount of water efficiently and uniformly. The ETc in inches per day for garbanzos grown in four different regions in California for four different planting dates (December, January, February, and March) is show in table 5. The cumulative seasonal ETc ranges from 18.3 inches to 26.4 inches, depending on the region and planting date. Table 5 can be used for both furrow and drip irrigation, as the charts for each irrigation practice are very similar, and most importantly, their peak period ETc is identical.

The amount of water needed from sprinklers to establish a garbanzo seed crop is about 2 to 4 inches in one to two applications, depending on rainfall. About 2 inches of water is needed for the Sacramento Valley and 4 inches is needed for the San Joaquin Valley. Sprinkler water would be part of the season ETc, so for estimating total water use, the 2 to 4 inches would be part of this. For example, for Zone 14 for a December 1 planting date, 2 inches would come from sprinklers and 22 inches from subsurface drip for a total 24 inches of water applied.

Drip Irrigation

Subsurface drip and sprinkler system efficiencies are typically 85 to 95 percent. Therefore, additional water may need to be applied to account for the distribution uniformity (DU) of the system. The irrigation amount to account for irrigation efficiencies is determined as follows:

$$\text{Irrigation amount} = [\text{Crop evapotranspiration} \div \text{DU (\%)}] \times 100$$

If the crop water requirement (ETc) under a drip system is 20 inches and the DU is 90%, 22.2 inches of water would need to be applied [(20 in. ÷ 90) x 100 = 22.2 in.].

Furrow (Flood) Irrigation

Furrow irrigation systems are not as efficient as subsurface drip systems due to water losses from tailwater runoff, deep percolation losses from ditch seepage, and overirrigation on all or parts of the field. Once the water passes below the garbanzo root zone, it is lost to deep percolation. In general, furrow systems are about 75 percent efficient. If the total garbanzo ETc is 20 inches and the furrow irrigation system had a 75 percent application efficiency, 26.7 inches of water would need to be applied, using the above equation, but substituting application efficiency for distribution uniformity.

Soil Moisture Monitoring

Soil moisture can be assessed with probes and using the “look and feel” method. However, moisture sensors can provide more accurate information. There are many sensor options available to growers, including tensiometers and gypsum blocks, that are accurate, relatively easy to use, and inexpensive. Tensiometers indicate soil moisture levels by measuring the soil moisture tension, or how strongly water is held onto soil particles. The higher the tension, the more difficult it is for plant roots to extract water from the soil.

Table 5. Average crop evapotranspiration (ETc) in inches per day for garbanzo beans planted on December 1, January 1, February 1, and March 1 for Zones 12, 14, 15, and 16. These tables can be used for both furrow and drip irrigation. The garbanzo crop coefficients used were developed by Rinaldi et al. 2008.

December 1 Planting Date				
Zone	*12*	*14*	*15*	*16*
Dec 1–15	0.02	0.03	0.02	0.03
Dec 16–31	0.02	0.02	0.02	0.02
Jan 1–15	0.02	0.02	0.02	0.02
Jan 16–31	0.02	0.03	0.02	0.03
Feb 1–15	0.03	0.03	0.03	0.04
Feb 16–28	0.04	0.04	0.04	0.05
Mar 1–15	0.06	0.07	0.07	0.08
Mar 16–31	0.11	0.12	0.12	0.13
Apr 1–15	0.17	0.17	0.19	0.19
Apr 16–30	0.21	0.21	0.23	0.23
May 1–15	0.24	0.24	0.27	0.27
May 16–31	0.26	0.25	0.27	0.28
June 1–15	0.20	0.20	0.21	0.22
June 16–30	0.13	0.13	0.13	0.14
Seasonal total, inch	**23.1**	**24.0**	**25.2**	**26.4**

January 1 Planting Date				
Zone	*12*	*14*	*15*	*16*
–	–	–	–	–
–	–	–	–	–
Jan 1–15	0.02	0.02	0.02	0.02
Jan 16–31	0.02	0.03	0.02	0.03
Feb 1–15	0.03	0.03	0.03	0.04
Feb 15–28	0.04	0.04	0.04	0.05
March 1–15	0.05	0.05	0.05	0.06
Mar 16–31	0.08	0.08	0.08	0.09
Apr 1–15	0.14	0.14	0.16	0.16
Apr 16–30	0.21	0.21	0.23	0.23
May 1–15	0.24	0.24	0.27	0.27
May 16–31	0.27	0.27	0.29	0.30
June 1–15	0.22	0.22	0.23	0.24
June 16–30	0.13	0.14	0.14	0.15
Seasonal total, inch	**22.0**	**22.4**	**23.8**	**24.8**

February 1 Planting Date				
Zone	*12*	*14*	*15*	*16*
Feb 1–15	0.03	0.03	0.03	0.04
Feb 16–28	0.04	0.04	0.04	0.05
Mar 1–15	0.05	0.05	0.05	0.06
Mar 16–31	0.06	0.07	0.07	0.07
Apr 1–15	0.08	0.08	0.09	0.09
Apr 16–30	0.16	0.16	0.18	0.18
May 1–15	0.24	0.24	0.27	0.27
May 16–31	0.27	0.27	0.29	0.30
June 1–15	0.25	0.25	0.26	0.28
June 16–30	0.14	0.15	0.15	0.16
Seasonal total, inch	**20.2**	**20.5**	**21.9**	**22.7**

March 1 Planting Date				
Zone	*12*	*14*	*15*	*16*
–	–	–	–	–
–	–	–	–	–
March 1–15	0.05	0.05	0.05	0.06
Mar 16–31	0.06	0.07	0.07	0.07
Apr 1–15	0.08	0.08	0.08	0.09
Apr 16–30	0.11	0.11	0.12	0.12
May 1–15	0.21	0.21	0.23	0.23
May 16–31	0.27	0.27	0.29	0.30
June 1–15	0.27	0.27	0.28	0.30
June 16–30	0.16	0.16	0.16	0.18
Seasonal total, inch	**18.3**	**18.5**	**19.8**	**20.5**

Therefore, low soil moisture tension indicates moist soil, and high soil moisture tension indicates dry soil. Gypsum blocks buried in the soil measure the electrical resistance of water, which can be converted into a soil moisture tension value. Soil moisture tension is usually expressed in centibars (cb).

Soil moisture sensors must be installed in areas that are representative of the field. That is, the site must have a soil type that is typical of the field and it needs to receive full irrigation coverage. Sensors should be installed to the depth of the active root water uptake zone, which for garbanzos would be about 4 feet (fig. 7). Monitor soil moisture at the 1-foot, 2-foot, 3-foot, and 4-foot depths to determine when to irrigate and to ascertain the depth or adequacy of an irrigation. It may also be useful to monitor at 5 feet to determine whether excess irrigation water is being applied, causing water to percolate past the garbanzos' 4- to 5-foot rooting depth.

INTEGRATED PEST MANAGEMENT (IPM)

Weeds, insects, and diseases are problematic in garbanzo bean production and must be monitored from planting to dry down. These can be managed and controlled through a combination of practices including using certified seed (disease and weed free), varietal host plant resistance, crop rotation, best planting dates, and pesticides. For more information on IPM in garbanzo production and photos of insect pests and diseases, see the *UC IPM Guidelines for Dry Beans* (UC IPM 2018). Nematodes can infest garbanzos, but have not typically been observed to be a problem in garbanzo production in California due to cooler, unfavorable soil temperatures during early-season plant growth.

Weeds

Garbanzo beans have a long growing season (December to June), requiring both winter and summer weed control for optimal production. Crop growth is slow through February, so winter weed competition can be high. As conditions warm in March, garbanzo growth increases, but by this time spring and summer weeds begin germinating and can compete extensively with the crop if left uncontrolled. With very limited postemergent weed control options in garbanzos and limitations on the residual activity of preemergent herbicides, a combination of management practices and herbicides is needed to control weeds in this crop.

Agronomic Practices

Prior to planting, weeds must be controlled, either either via a preplant glyphosate application (e.g., Roundup) or mechanical or lightly harrowing. At planting time, drilling seed into moisture rather than irrigating up gives seedlings a head start against emerging weeds. However, in the south San Joaquin Valley, where rainfall is limited, growers generally plant dry and then irrigate up using hand-line sprinklers, which also activates soil-applied preemergent herbicides. Higher planting densities can also help garbanzos compete better against weeds, such as 3 rows versus 2 rows on 60-inch beds.

Prior to row closure, a mechanical cultivation helps control weeds (fig. 8). Take care not to prune the garbanzo roots to avoid

Figure 8. Cultivating garbanzo beans. Photo: R. Long.

damage and yield reduction. Finally, it is critical to control weeds with crop rotation to ensure as little weed competition as possible when growing garbanzos. Rotating to other crops, such as corn or cereal grains, where available herbicides suppress troublesome weeds (especially broadleaves), can reduce the weed seed pressure in garbanzo production.

Common Weed Species

Problem winter weeds common in garbanzo beans include mustards (*Brassica* spp.), wild radish (*Raphanus raphanistrum*), London rocket (*Sisymbrium irio*), prickly lettuce (*Lactuca serriola*), shepherd's-purse (*Capsella bursa-pastoris*), and sowthistle (*Sonchus* spp.). Spring-germinating weeds include redroot pigweed and other *Amaranthus* spp., nightshade (*Solanum* spp.), common lambsquarters (*Chenopodium album*), nightshade (*Solanum* spp.), knotweed (*Polygonum aviculare*), and Russian thistle (*Salsola* spp.). Become familiar with these weeds in the field to make sure the right herbicide is selected to control them (for weed identification resources see the Weed Research and Information Center website, http://wric.ucdavis.edu/, and UC IPM websites). In addition, always watch the timing of the herbicide application and the variety of the dry bean, as there are restrictions for herbicide use in garbanzo beans that do not occur for other bean classes.

Herbicides

A standard herbicide program for garbanzo beans includes preemergent herbicides that are sprayed on the beds after the crop is planted but before the crop and weeds emerge. These herbicides must be applied within 2 days after planting and are activated by rain or sprinklers (0.5 to 1 inch) and often include Chateau (flumioxazin). Goal (oxyfluorfen) can be used in place of Chateau, but Goal always causes at least some phytotoxicity to garbanzo seedlings, though more under rainy or foggy conditions at or after emergence, a result of both soil barrier contact injury and volatilization or "lift-off" in water vapors. However, the plants will recover with no impacts on yield. Chateau has been reported to volatize and injure newly emerging garbanzo seedlings planted into moisture if it is not incorporated by water prior to crop emergence. Metribuzin is also available but provides only partial control of nightshade species. In addition, crop injury can occur with metribuzin under rainy (wet) and cold conditions. Weeds that are particularly difficult to control such as field bindweed (*Convolvulus arvensis*) and nutsedge (*Cyperus* spp.) can be controlled with glyphosate on preformed beds before planting.

Weeds can also be controlled with the preplant incorporated herbicide Treflan (trifluralin) sprayed broadcast, then mechanically incorporated 2 to 4 inches deep, typically by using two passes of 4-inch-deep chisels, disks, or rollers. Treflan is volatile and needs to be incorporated into soil with adequate moisture within 24 hours of application. Dual Magnum (metolachlor) or Prowl (for spring plantings) can be tank mixed with Treflan for a greater spectrum of weed control. Dual Magnum controls yellow nutsedge, but it can injure crops in cold, wet soils where garbanzos are planted deep into moisture.

No postemergent broadleaf herbicides are registered for garbanzos, except shielded sprays with Shark (carfentrazone), which must be kept off the garbanzo foliage to prevent crop injury. Grasses can be controlled postemergence with Select Max (clethodim) or Poast (sethoxydim). Poast is particularly useful in controlling volunteer grasses if garbanzos follow a grain crop. Both herbicides must be combined with a crop-oil concentrate, and the spray solution must be buffered if using hard water with high pH.

Insects

Soilborne Insect Pests

Symphylans, or garden centipedes (*Scutigerella immaculata*), cutworms (various species, including black and variegated), wireworms (*Limonius* spp.), and seed corn maggot (*Delia platura*) live at or below the soil line and can seriously damage garbanzo seedlings, resulting in significant stand losses. These pests tend to be sporadic in time and space with patchy distribution in fields. In general, they seem to be more troublesome in wet years when a lot of weed vegetation or previous crop residue is present in the field. Soil pests tend to be problematic in the same field year after year, so being familiar with the history of the field is important for managing these pests in cropping rotations. Management practices include monitoring for pests and using insecticide and fungicide seed treatments, insecticidal baits, or soil-incorporated insecticides in problem fields, as discussed in the *UC IPM Guidelines for Dry Beans* (UC IPM 2018).

Foliar-Feeding Insect Pests

The acid-secreting glandular hairs on garbanzo plants make them less attractive to insect pests and provide some degree of protection against aphids. However, a number of pests must be monitored continually until plant dry-down using a standard sweep net. Armyworms (*Spodoptera* spp.) and corn earworm (*Helicoverpa zea*) are uncommon in garbanzos, but they can damage the crop in some years. Lygus bugs and stinkbugs can also damage seeds when the pods are in the immature (green) stage of development.

Thresholds

There are no established economic thresholds for insect pests in garbanzos. If small worms, lygus bugs, or stinkbugs are found throughout the field when young pods are on the plants and are obviously causing damage, they should be controlled with insecticides. In addition, watch for leafminers (*Liriomyza* spp.), the tiny larvae of flies that leave behind white trails when they feed on leaves, as heavy infestations can cause significant damage.

Aphids do not reproduce on plants due to acids that the plants secrete that generally kills them. However, they can vector diseases, as described in the following section, but insecticide sprays are not recommended because by the time you see the plant damage, the aphids will be gone.

Diseases

Seedling Diseases

Kabuli-type garbanzos have a thin seed coat that lacks the phenolic compounds that resist infection by soil fungi (as found in Desi types) and are susceptible to infection by soilborne pathogenic fungi. Therefore, seed fungicide treatments are highly recommended and have been shown to improve stands, especially in the Sacramento Valley, where plant growth is slower due to cooler soil temperatures, favoring pathogens (see the seed treatment recommendations in UC IPM 2018). Proper seed placement is also important; if garbanzos are planted too deep in heavy cold, wet soils, they will be susceptible to seed rot, regardless of whether the seed is treated or not.

Damping off, a weakening of seeds or seedlings before or after they germinate, is generally caused by two fungi, *Pythium ultimum* and *Rhizoctonia solani. Pythium* sp. generally causes preemergence root rot. This fungus thrives particularly well in cool, wet soils that often occur in low spots of a field where water pools or in soils that are irrigated up, which can result in saturated soils at germination. *Rhizoctonia* generally causes postemergence damping off of seedlings. This disease infects the root, producing a sunken, oval-red brick lesion that often extends around the root. Most damage by *Rhizoctonia* occurs in warm soils during the first 6 to 8 weeks after germination. *Pythium* resistance to Apron (mefenoxam) has been reported in the Pacific Northwest states, but not in California.

Charcoal Root Rot

Charcoal root rot, or ashy stem blight, caused by *Macrophomina phaseolina* infections, begin on the bean stems at or below soil level and extend down into the roots and up into the branches. Lesions enlarge and turn ashy-gray, with numerous black fruiting bodies on the gray background. Infection is usually on young plants, which usually die before setting seed. This disease is most serious during periods of high irrigation moisture and high air temperatures (especially above 80°F). Garbanzos that are produced on cooler soils in the coastal valleys (such as the Central Coast or the Salinas Valley) and in some years the San Joaquin Valley generally do not get this disease even if it is present in the soil. The fungus is also pathogenic on sunflower, sorghum, and corn. Avoid drought stress, especially during periods of high temperature. A 3-year rotation with a cereal crop may help reduce the disease pressure.

White Mold

This foliar disease, caused by *Sclerotinia sclerotiorum,* can be a serious problem in California garbanzo bean fields, depending on environmental conditions. It is characterized by a white fungal growth that attacks the aboveground plant parts (particularly near the soil line for garbanzos) during prolonged cool, wet conditions, causing the plants to wilt and die. Favorable disease conditions occur from 68° to 77°F. Blackened sclerotia sporelike bodies, formed in the mold, drop to the ground and can survive many years in the soil and reinfect many different crops, as *Sclerotinia* has a wide host range. The development of white mold is greatly influenced by prevailing weather conditions and certain agronomic practices. For example, a thick, dense plant growth favors cool, moist conditions beneath the plant canopy that are favorable for disease development.

For management of white mold, consider a wider row spacing. This increases air movement in the canopy and may help keep the foliage drier, reducing favorable conditions for infection. In addition, avoid heavy nitrogen applications, which can produce excessive canopies. Plant garbanzos later (December through early February) rather than earlier (November), since the extra growing time can result in heavy canopies that increase humidity and the potential for infections late winter or early spring. Fungicides such as Endura (boscalid) are available for white mold control, but getting good coverage and control is difficult because the inoculum is in the soil and the disease is often deep in the plant canopy. Fungicides would have to be applied when plants are smaller to provide good coverage and protection from this disease. Crop rotation with nonhosts, such as small grains and corn, may reduce the soil inoculum.

Ascochyta Blight

This fungal disease, caused by *Ascochyta rabiei* (or *Didymella rabiei*), is favored by cool, wet weather and can readily destroy garbanzo crops if left uncontrolled. *Ascochyta* infects all aboveground plant parts, causing plants to turn yellow and dieback. Dark brown lesions form on the stems, leaves, and pods, causing branches to drop. In advanced stages of disease development, small black spots (pycnidia, or fungal structures that produce spores) form concentric circles in the lesions and are a good diagnostic characteristic of the disease. This pathogen is spread by infected seed, rain splash, wind, garbanzo residue, and volunteer garbanzo plants.

Ascochyta blight is controlled by crop rotation of at least 2 to 3 years to eliminate the fungus. Garbanzos are the only host, but it may take several years for the garbanzo residue to fully decompose in soil in dry climates like California. To keep Ascochyta blight out of fields, plant resistant varieties (see table 1), use certified seed, and treat the seed with a fungicide such as Mertect (thiabendazole). Monitor the crop and, if necessary, apply a foliar fungicide such as Quadris (azoxystrobin). Destroy and bury all crop residue and volunteer garbanzo beans in and around fields to keep the disease pressure to a minimum.

Fusarium Wilt

This fungal disease, caused by *Fusarium oxysporum* f. sp. *Ciceris,* is a serious disease of garbanzos worldwide that can attack and kill the plant at any stage. So far, this disease has only been recorded on the Central Coast of California. Early wilt symptoms (within 25 days of sowing) include drooping leaves, a dull green discoloration, and collapse of the entire plant. Later wilt symptoms, 6 to 8 weeks after sowing, include leaf droop followed by yellowing and necrosis of the foliage. Late wilt may affect only a few branches of a plant, resulting in partial wilt, or it may cause wilting of the whole plant. Roots of affected seedlings and plants show no external root discoloration; however, the stems develop a dark brown discoloration of vascular tissue in the center (xylem) that can be seen when they are split vertically or cross-sectioned. Affected plants may be grouped in patches or appear spread across a field. Fusarium wilt is seedborne (in and on seed coats) and can also be spread via contaminated soil on equipment. Control practices involve planting resistant varieties where the disease is prevalent (see table 1), using certified seed, and cleaning equipment when moving between fields. A discussion of the history of Fusarium wilt in California and breeding for resistance can be found in Helms 1993.

Fusarium Root Rot

This root disease is caused by the fungus *Fusarium solani f. sp. pisi* and attacks the underground stems and roots of plants. Early infection is characterized by elongated reddish streaks; eventually a reddish-brown lesion will surround the entire root, causing root decay and leading to stunting, yellowing, wilting, and dieback of plants. This Fusarium root rot is very specific to garbanzos and other beans, as well as field peas. For example, in San Luis Obispo County, winter peas followed by spring garbanzo plantings resulted in several infected fields. Plants are more susceptible to this disease when they are stressed, such as under drought or waterlogged conditions. There has been no screening for varieties resistant to Fusarium root rot, but in field observations, varieties such as San Joaquin show some tolerance for this disease. Seed treatments help manage this disease (UC IPM 2018).

Viruses

Garbanzo beans have a number of viral diseases, including *Alfalfa mosaic*, *Beet western yellows*, *Subterranean clover red leaf*, *Legume yellows*, *Lettuce mosaic*, and *Cucumber mosaic*. All viruses of garbanzos are vectored by aphids, including pea aphid (*Acyrthosiphum pisum*), cowpea aphid (*Aphis craccivora*), and green peach aphid (*Myzus persicae*). It is difficult to differentiate between the viral diseases, and identification generally requires genetic testing from plant pathology diagnostic labs.

The plant symptoms of viral infections include yellowing (brighter than Fusarium wilt or Fusarium root rot), wilting, stunting, and dieback. The degree of plant loss and yield decline depends on the timing of the infection (later infections may not be as damaging) and the viruses involved. A common theme for viral infections in garbanzos is that there is no pattern to the disease incidence in the field. That is, individual plants scattered throughout the field may show dieback. This is because the infection depends on where the aphids land and feed. Aphids do not colonize (reproduce) on plants due to the acids secreted by the plants. Instead, they usually die, so there is minimal lateral spread of the disease from the point of infection.

To identify a viral infection, cut a stem longitudinally and observe any discoloration. If discoloration is in the center of the stem, it is likely the xylem (water-conducting tissue) and thus Fusarium wilt (the infected xylem tissues are dark brown to almost black). If the brownish discoloration runs along the edges of the cut stem, it is in the phloem (sugar-conducting tissue) and caused by an aphid-transmitted virus.

Alternate hosts of the viral diseases include weeds, alfalfa (for *Alfalfa mosaic virus*), and other legumes. Years of having little or no winter rainfall may result in very modest aphid and virus pressure until the late part of the growing season, likely due to fewer weed hosts surrounding fields during drought years. In areas where garbanzo bean plantings are common, the incidence of viruses is correlated with aphid flights in October to November and March to May. Avoid planting garbanzos during aphid flights, control adjacent weeds, and do not plant garbanzos next to alfalfa fields where they can pick up and transmit *Alfalfa mosaic virus* (lima beans are also very susceptible to this virus).

Harvesting and Markets

Garbanzos generally mature (senesce, or dry down) in the Central Valley in June and are ready to harvest in July. The stage of maturity at harvest is critical for maintaining a quality product for both canning and packaged seed. The optimal moisture content at harvest for garbanzos is 10 to 12 percent. However, the reality is that beans are often harvested at 7 to 8 percent due to a delay in the availability of grain harvesters, which are often tied up in the wheat harvest. Beans with higher moisture discolor and turn gray in storage. Harvesting too late and too dry may cause excessive shattering of pods and lower yields. All pods should be yellow or dry at the time of harvest.

Garbanzo seeds are tougher and the plants are taller than other dry bean crops, allowing for direct harvesting with a regular combine header (fig. 9). To maintain canning quality, avoid cracking or splitting the seeds during harvest. The main adjustments to check when harvesting are cylinder clearance and speed. Start at the lowest speed and increase the speed as necessary, watching for seed quality. Harvested seed is taken to seed processors for cleaning and grading. Afterwards, the garbanzos are usually stored at the processor's warehouse until sold for canning, packaged beans, or planting seed. Seeds must be stored at a moisture content of 8 to 10 percent to prevent discoloring.

Figure 9. Harvesting garbanzo beans with a grain combine.
Photo: R. Long.

Diseases and insect pests are generally controlled by fumigation in the warehouse.

Markets

Garbanzo beans are farmed on a contract basis for the canning and dry packaged bean industry in California. Most of the production is for domestic use (over 90 percent), with a small amount going to overseas markets, including Asia. Our Mediterranean climate, where little rainfall occurs from pod set through harvest, provides ideal climate conditions for producing the high-quality, creamy colored garbanzo beans that meet industry needs. Garbanzo varieties adapted for California production maintain firmness after canning, have a uniform seed size (about 60 beans per ounce), sustain a light golden color, and have minimal starch leakage from splits and cracks or skin peeling. High-quality beans are also maintained by production fields that are almost entirely free of weeds, pests, and diseases. Although garbanzo acreage is small in California, the state competes well with other countries that produce Kabuli-type beans, such as Mexico, by producing high-quality beans for a specialty market for canning quality beans, often destined for garnishes at salad bars.

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