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Common Dry Bean Production in California

Second Edition

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Contents

Introduction

Common dry beans include the market classes kidney, cranberry, pink, black, white, yellow, pinto, and red, all of which are different types of a single species *(Phaseolus vulgaris)* that was originally domesticated several thousand years ago in the areas that are now Mexico and South America. Natural selection and breeding programs lead eventually to the current market classes, which are mainly distinguished by seed size, color, and shape, and plant growth habit. Currently, there are no commercially available genetically modified varieties of *P. vulgaris.*

Dry beans are grown in California mainly for human consumption, though a limited but stable acreage is dedicated to seed production. Dry beans are nutritious: they are high in starch, protein, and dietary fiber, they have no cholesterol, and they are an excellent source of iron, potassium, selenium, molybdenum, thiamine, vitamin B6, and folic acid. The U.S. Department of Agriculture considers dry beans to be both a vegetable and a protein source.

In California, dry beans have been an important crop for more than a century. They fit well into crop rotation plans by adding to the diversity of crop choices growers have available for production and marketing and providing consumers with healthy food choices. Dry beans also benefit the soil because, as legumes, they fix nitrogen from the air and leave some in the soil after harvest. The primary growing areas are the Sacramento and northern San Joaquin Valleys. Acreage data by market class are shown in Table 1. Growers sometimes double-crop dry beans following wheat or other cereal grains.

Dry beans generally are grown under contract with marketing warehouses, most of which are located in California. Some growers also direct-market their beans locally, at farmers markets for example. A good variety of information on marketing beans is available through the California Bean Shippers Association (www.calbeanshippers.org), a group made up of handlers, warehouses, and exporters that focuses its efforts on expanding the dry bean industry in California. Growers in the state pay an assessment to the California Dry Bean Advisory Board (www.calbeans.com), a marketing order that provides funding for both research and promotion of California-produced dry beans.

Variety Selection

The range of commercially available bean cultivars and varieties in different market classes is constantly changing. New cultivars are released for their increased yield potential, pest and disease resistance, full-season and early double-cropped growth potential, and improved market quality. Public (university-based) and private plant breeders develop new varieties by adding desirable features to old cultivars or create new and better cultivars by recombining the best traits from available germplasm. They accomplish this breeding process through conventional hybridizations and selection for specific traits, not through genetic engineering.

In choosing a dry bean variety, a grower should consider its disease resistance, growth habit, days to maturity, seed quality, seed yield potential, area of adaptation, and potential marketability. Characteristics of common dry bean market classes and varieties grown in California are shown in Table 2. You can also get help selecting bean varieties by asking your local University of California Farm Advisor (see www.ucanr.org), warehouse workers, and commercial seed handlers or their local representatives.

Dry edible bean plants have one of two basic plant types, or growth habits: determinate (bush) type and indeterminate (vine) type. In the determinate bush type, stem elongation ceases when the terminal flowers of the main stem or

Table 1. Common dry bean acreage by market class in California, 2003–2008

	Acreage (thousands)*					
Year	**Light red kidney**	**Dark red kidney**	**Cranberry**	**Pink**	**Black**	**Other†**
2003	4.9	0.9	1.5	0.9	0.4	6.9
2004	4	1.1	1.6	0.3	0.7	7.0
2005	3.5	1.2	1.1	0.3	0.4	NA
2006	1.9	0.4	0.8	0.2	0.6	8.1
2007	1.5	0.5	0.8	—‡	0.4	7.1
2008	2	0.6	1.3	—‡	—‡	7.4

**Source:* USDA-NASS and the California Dry Bean Advisory Board.
†Includes large whites, canario, and miscellaneous heirloom varieties.
‡Pink and black beans were included with "Other" category for 2007–2008.

Table 2. Characteristics of common bean cultivars grown in California based on statewide variety testing. All varieties listed are resistant to one or more strains of bean common mosaic virus (BCMV), a seedborne disease vectored by aphids

Market class and variety	Plant characteristics	
	Growth habit	**Days to maturity***
Light red kidney		
CA Early Light Red	bush	65–75, early
Red Kidney M	bush	75–90, moderate
Sacramento	bush	75–90, moderate
Dark red kidney		
CA Dark Red Kidney	bush	75–90, moderate
UC Nichols	bush	90–105, moderately late
Cranberry		
Etna	bush	65–75, early
Hooter	bush	65–75, early
Pink		
Yolano	vine	75–90, moderate
Black		
Black Turtle T-39	vine	105+, late
Midnight	vine	105+, late
Large white		
Cyrrus	bush	75–90, moderate
Yellow		
Canario 707	bush	90–105, moderately late

*Days to maturity are from date of planting to date of cutting.

lateral branches have developed. On indeterminate vine types, flowering continues simultaneously with pod filling, or the two processes alternate; either way, flowering and pod filling continue for a longer period than for bush types. Most vine types tend to be more prostrate than bush types. Days to maturity refers to the number of days from planting to cutting. The plants need another 1 to 2 weeks after that for the crop to dry before the beans are harvested. All varieties listed in this publication are resistant to one or more strains of bean common mosaic virus (BCMV), a seedborne disease vectored by aphids.

Choice of Seed

Select bean-planting stock from lots that meet high performance standards, with seed germination of 85 percent or better and seedlings having no visible seedling defects. Seed for planting should be free of varietal mixtures, weed seeds, and foreign matter. By using certified seed, you ensure that you have seed of the best quality and keep the possibility of introducing seedborne diseases to a minimum. Serious diseases can be introduced at planting, especially if you use non-certified bean seed (whether from within California or out of state), and that can result in significant yield losses. Most bean seed comes pre-treated with fungicides to prevent damping-off from *Rhizoctonia*, *Pythium*, and other pathogens. When you plant earlier than May 20 in cooler soils, you increase the likelihood of soilborne root and seedling diseases, and in some cases the likelihood of predation by seed corn maggot larvae *(Delia platura)*.

When the seed arrives at your farm, handle the bags carefully: bean seeds are fragile and can sustain internal damage. Walking on bags, throwing or dropping them, or pouring the seed into hoppers from distances in excess of 2 feet can cause internal seed injury. Badly bent or curved seedlings, missing cotyledons, and “bald head” seedlings are the result. High-quality seed will germinate rapidly and produce good stands of vigorously growing seedlings.

Land Selection

Common beans grow best on deep, loamy soils without restrictive claypans, hardpans, or plowpans in the root zone. Soils that are high in clay content need to be managed carefully since they have the potential to remain saturated for long periods following irrigation. Saturated soils are detrimental to bean growth because the water replaces oxygen in the soil, resulting in reduced root growth and stand loss. In hot weather, excess water can cause physiological damage by “scalding” the plants. The ability of fungi to invade plant tissue is also enhanced in wet soils. Various root rots and wilts of bean plants occur under saturated soil conditions.

Avoid fields with salinity, alkaline, or boron problems. Of the field and vegetable crops grown in California, dry beans are among the least tolerant to salt and boron (Table 3). Common dry beans have a poorly developed, relatively inefficient root system. As a consequence, dry beans grown in soils high in silt, sand, or gravel (which do not absorb or hold moisture well) may not produce profitable yields. Blackeye bean, a type of cowpea *(Vigna unguiculata)*, is often a better choice for sandy or otherwise poor soils because it has a much more aggressive and efficient root system and moderately higher tolerance to salinity and boron. You should always rotate beans with other crops such as wheat, tomatoes, sunflower, and alfalfa to avoid the buildup

Table 3. Boron and salt tolerance limits of select field crops

Crop	Boron (ppm)	Threshold soil salinity*
Common dry beans, *P. vulgaris*	0.50 – 0.75	1.0
Lima beans, *P. lunatus*	0.75 – 1.0	1.5
Wheat	1.0 – 1.5	6.0
Blackeye or cowpea, *V. unguiculata*	2.5	4.9
Alfalfa	4 – 6	2.0
Tomatoes	5.7	2.5

*This value is the electrical conductivity of the saturated soil extract in dS/m (same as mmho/cm).

of fungal diseases such as *Rhizoctonia*, *Fusarium*, *Pythium*, *Sclerotium*, and *Sclerotinia* in the soil.

Fertilization

When soils are deficient in nitrogen (N), phosphorus (P), potassium (K), sulfur (S), and zinc (Zn), common dry bean plants are responsive to these fertilizers. Prior to planting, test the soil to determine the likelihood of crop response to P, K, and Zn fertilizer applications. Soil cores should be taken at 0- to 6-, 6- to 12-, and 12- to 24-inch depths. All three depths should be analyzed for nitrate-N. Phosphorus, K, Zn, and pH readings are taken from the 0- to 6-inch sample. The pH of a soil should be between 6.0 and 8.0 for good bean production. Consider applying lime to those soils that have a pH below 5.5. Readings on salinity, boron content, or both should be determined on samples from all three depths if you have reason to suspect a salt or boron toxicity problem. Any knowledge of the field's history and any past nutrient problems (such as sulfur and boron deficiencies or salt or boron toxicities) should be taken into consideration before you plant a dry bean crop.

Organic production of dry bean crops involves the application of manures and other slow-nutrient-release materials that need to be incorporated into the soil prior to planting. If you have your soil test results well ahead of time, you will have an easier time developing nutrient management plans. Three to five tons per acre of one of several types of animal or poultry manure will often be sufficient to supply all of the nutrient requirements for the bean crop. You will also want to look at the economics of applying other types of acceptable nutrient sources. For growers transitioning into organic bean production on soils that require large applications of phosphorus, potassium, zinc, or possibly lime, it may be more economical to build up the soil fertility first with synthetic fertilizers and focus on weed and insect control prior to the 3-year transition period to organic production.

Nitrogen

Dry bean seed has a protein content of about 24 percent and a nitrogen (N) content of 4 percent. This means that to achieve a 2,000 lb per acre yield, the dry bean seed crop needs at least 80 lb of nitrogen per acre. In addition, 20 to 40 lb of nitrogen are needed for the plant itself. About 20 to 40 percent of the nitrogen needed will probably be supplied from nitrogen-fixing nodules on the plants' roots, but the rest has to come from another source of nitrogen. This is particularly true for early maturing bush varieties that need a readily available source of nitrogen in order to achieve high yield potential in a short time.

Many legumes have the ability to fix nitrogen from the air if they are inoculated with specific *Rhizobium* nitrogen-fixing bacteria. It is always desirable, therefore, to inoculate the bean seed with the host-specific *R. phaseoli,* especially if dry beans have not been grown in the field for the past 10 years. Unlike alfalfa and several nitrogen-fixing crops, the relationship between dry beans and *R. phaseoli* is not able to provide sufficient nitrogen to sustain high crop yields. This is generally true of the grain legumes, where a large percentage of the plants' nitrogen is in the grain or seed. Dry, hot weather and periods of soil water saturation will further reduce nitrogen fixation levels. Nitrogen fertilizer applications help ensure that the plants receive enough nitrogen for rapid growth and high yields.

Background nitrogen levels in the soil (nitrate-N in the top 24 inches as determined by a soil test), if not leached by irrigation, should be taken into account before you determine the application rate for sidedress-applied nitrogen.

General fertilization of dry beans includes a starter fertilizer of 8–24–6 band-applied during planting at the rate of approximately 200 lb (dry fertilizer) or 20 gallons (liquid fertilizer) per acre. At layby (prior to row closure from developing plants), fields should be sidedressed (injected) during cultivation with aqua ammonia or a similar nitrogen fertilizer at 70 to 100 lb of nitrogen per acre.

Table 4. Phosphorus recommendations for dry 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 HCO_3-P	0–3	4–7	8–11	12–15	16+
Yield goal (lb/a)	**Application amount (lb P_2O_5/acre)**				
1,800	35	25	15	0	0
2,000	45	30	20	10	0
2,200	50	35	20	10	0
2,400	55	40	25	10	0

Phosphorus

If a representative soil test indicates a phosphorus (P) deficiency, make corrections with a starter fertilizer containing this element at the rate indicated in Table 4 as pounds of P_2O_5 per acre. 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 low and very low extractable phosphorus levels would be expected to show a yield response to phosphorus fertilization. Crops grown in soils that test in the moderate range are less likely to respond to phosphorus fertilizer applications. Adequate phosphorus levels are important for strong seedling growth.

Potassium

Potassium (K) should be applied as recommended in Table 5. Soil test (ammonium acetate exchangeable K) results that fall in the very low range would indicate that plants should respond to potassium fertilization. Test levels in the low range indicate that the plants are less likely to respond to potassium applications. If a representative soil test indicates a potassium deficiency, you can correct it with a starter fertilizer containing potassium at the rate indicated in Table 5 as pounds K_2O per acre. There are few California soils in the common bean growing areas that have potassium deficiencies severe enough to limit yields.

Sulfur

Sulfur (S) deficiencies may be observed in common beans. Some soils in the Sacramento Valley are likely to be deficient in sulfur, and most irrigation water contains little or no sulfur. Fertilizers such as ammonium sulfate, which was a common source of sulfur in the past, are no longer being used as commonly as non-sulfur-bearing aqua ammonia and other high-analysis fertilizers.

The newer solution is to broadcast elemental sulfur at a rate of 50 to 100 lb of sulfur per acre and incorporate it into soils, providing a correction that will last a number of years. You must make sure, however, to apply elemental sulfur far enough ahead of planting time to ensure it will have time to oxidize to sulfate-sulfur, the form used by plants. The time necessary to oxidize elemental sulfur depends upon soil temperature and moisture as well as the size of the sulfur 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 such as gypsum (calcium sulfate) that provide the readily available sulfate form of sulfur can also be used. These materials should be applied at a rate that supplies about 50 to 100 lb of sulfur per acre and should be incorporated into the top 2 to 3 inches of soil to be most effective.

Table 5. Potassium recommendations for dry beans

Soil test	Potassium (ppm)		
	Very low	Low	Moderate
Ammonium acetate exchangeable K	0–40	41–80	81–120+
Yield goal (lb/a)	**Application amount (lb K_2O/acre)**		
1,800	45	20	0
2,000	50	20	0
2,200	55	25	0
2,400	60	25	0

Zinc

Dry beans often respond to zinc (Zn) fertilizer in low-zinc soils, especially those that test below 0.5 ppm as DTPA-extractable zinc. These low-zinc soils may occur on low-organic-matter soils, some calcareous high-pH soils, some coastal acidic soils, or newly leveled land that required extensive cuts and fills. Zinc deficiency may be recognized in bean plants by bronzing, browning, and death of leaf tissue, stunting of plants, and poor vining. The best way to diagnose the zinc status of a field is to perform soil tests before planting or conduct tissue tests of the most recently matured leaves.

Where the deficiency is not severe, application of a mixed fertilizer containing zinc at 1 to 3 lb per acre in the starter fertilizer is usually sufficient. Zinc sulfate can be applied to established plants as a foliar spray at a concentration of 3 to 4 lb per 100 gallons of water to correct a zinc 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 upon the size of the plants. Chelated zinc may also be used as a foliar-applied correction.

In fields with severe zinc deficiency, you can apply a correction that will last for several years by incorporating zinc sulfate into the soil at a rate of 10 to 20 lb of zinc per acre. Zinc as zinc sulfate is not mobile in the soil, so you have to place it in the root zone for plant uptake.

Boron

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

Boron toxicity is likely if beans are grown in the high-boron soils on the west side of the San Joaquin Valley, parts of Yolo County, and several other areas in California. Irrigation water can also be a source of boron toxicity for beans. Toxicity symptoms include yellowing of the leaf tips, interveinal chlorosis, and progressive scorching or death of the leaf margins. While dry common beans are known for their low tolerance to excess boron, recent studies suggest there may be more genetic variability in the crop than was previously known, suggesting the possibility that varieties might be developed that have more tolerance to boron.

There is a narrow range between deficiency and toxicity for sensitive crops such as dry beans, since a little too much boron will reduce yields (see Table 3). Average boron concentrations measured in the youngest fully mature leaves can be used to estimate plant boron status as follows: deficient (less than 15 ppm boron), sufficient (20 to 50 ppm boron), high (50 to 100 ppm boron), and excessive or toxic (over 100 ppm boron). The recommendation for soil application of boron is 0.5 to 1 lb per acre, while the suggested rate for foliar application is 0.1 lb of boron per acre, mixed in 30 gallons of water. The boron fertilizer used most frequently is sodium borate, which ranges from 10 to 20 percent boron. "Solubor" is a trade name for a sodium borate that is 20.5 percent boron. This fine, granular material is commonly applied as a foliar spray or in liquid fertilizers.

Fertilizer Application

Exercise particular care with starter fertilizer placement to avoid causing 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, you should place fertilizer so that it will be no closer than about 2 inches to the side and about 2 inches below the bean seed.

Crop Rotation

Common beans are a warm-season crop. In California's Central Valley, they compete for land with cotton, corn, safflower, wheat, rice, alfalfa, tomatoes, and other vegetable and seed crops such as sunflower and cucurbits. They fit well as an intercrop in young orchards until tree growth interferes with the bean harvesting machinery.

Several disease-producing bean pathogens are either soilborne or come from the residue of previous bean crops. A three-year crop rotation pattern helps reduce carryover of most disease pathogens. A good rotation plan stipulates that beans will not be grown in consecutive years. Beans planted after another bean crop may do poorly because of diseases such as *Rhizoctonia*, *Pythium*, and *Sclerotinia*, which tend to build up in the soil.

In contrast, beans following a corn, alfalfa, or cereal grain crop are generally free of seedling diseases. In a short rotation, beans produce best following a cereal crop. The presence of beans in a crop rotation plan may also improve soil tilth and increase soil nitrogen, benefiting subsequent crops.

Land Preparation

Land preparation for beans is the same as for corn, sunflower, and other row crops, leaving a final seedbed that is free of large clods and in such condition that the planted seed will have contact with fine, firm, moist soil particles to facilitate rapid germination. Consistent seed depth is critical to a good stand. A cloddy field is not just a poor environment for bean seed germination; it also prevents herbicides from incorporating properly into the soil.

For single-cropped fields, usually the ground is disced twice with a finishing disc prior to listing the bed. In the fall, six rows of beds set 30 inches apart are listed per pass. Some growers use three beds 60 inches wide. Winter weeds are controlled around February with Roundup (glyphosate) applications. For double-cropped fields, discing and listing beds generally occurs in June, after the wheat or other winter cereal is harvested, although some growers plant directly into the wheat or other small grain crop without re-working the beds.

Prior to planting, pre-plant herbicides such as Treflan HFP and Dual Magnum are sprayed onto the soil and mechanically mixed in with two passes of a finish disc. A starter fertilizer of 8–24–6 is then applied just before planting at the rate of 20 gallons per acre. The fields are then pre-irrigated, and the beans planted at 50 to 75 lb per acre, depending on the variety. Use extreme caution when using power-driven equipment following a pre-irrigation to avoid working the soil when it is too wet. If it is tilled too wet, tillage may cause a “slick pan” to develop at seeding depth that will impede root penetration, resulting in poor seedling development and plant growth. An excellent and uniform pre-plant irrigation and careful bed preparation are keys to obtaining a good stand of beans.

Planting

Most common beans are planted in single rows on 30-inch beds or in two rows on 60-inch beds with a 26-inch spacing between the rows. Appropriate planting equipment includes John Deere flex-planters or air seeders that are used for other row crops. Avoid cracking or crushing bean seed in the plate planters. Some growers routinely add a small amount of graphite to each planter box when it is filled with seed to enhance seed movement inside the boxes. Granular Rhizobium inoculant is best applied using separate metering boxes attached to the bean planter and through separate tubes and shanks that place the inoculant slightly below and to the side of the planted seed. You can also use powdered inoculant, but granular forms are better suited to the crop, especially if the bean seed has been treated with a fungicide.

Planting rates on a pounds-per-acre basis vary considerably due to the inherent seed sizes and shapes of different bean varieties. Regardless of seed size, most common beans are planted at a rate of about four to six seeds per foot of row in 30-inch row plantings. This amounts to 69,696 and 104,544 bean seeds per acre at four and six seeds per foot, respectively (Table 6). Table 7 shows the pounds of seed required for several different varieties planted at 2-, 3-, and 4-inch spacings, but check with your local seed company regarding their own specific recommendations for the variety of bean seed you are planting.

Table 6. Seeds per acre as affected by the number of seeds per foot in 30-inch row spacings

Number of seeds per foot of row	Seeds required per acre with a 30” row spacing
2	34,848
3	52,272
4	69,696
5	87,120
6	104,544

Table 7. Comparable seeding rates of selected bean varieties spaced 2, 3, or 4 inches apart in 30-inch rows. The number of seeds per acre from table 6 divided by seeds per pound will yield the pounds of seeds required per acre.

Variety	Approximate seeds per pound	Pounds of seed per acre, using 30-inch rows		
		Planted 2" apart	Planted 3" apart	Planted 4" apart
Kidney	758	138	92	69
Pink	1,620	65	43	32
Black	2,268	46	31	23

A good time to plant dry beans in the Central Valley is after May 15, when soil and air temperatures are high enough for rapid seed germination and emergence. Place seed 1 to 2 inches deep into firm, moist soil, with no more than an inch of drier soil above the moist soil. If drying winds are a problem, seed may be placed somewhat deeper into moisture. If soil moisture is lost after planting, irrigate to germinate the seeds with a short irrigation set; too much water at this point would cause saturation and seedling disease problems. If crusting occurs over the seedbed after planting, use a lightweight brillion roller to break up the crust to encourage seedling emergence and prevent seedling diseases. More stand problems are attributable to planting too deep than to planting too shallow, and most stand problems trace back to pre-plant practices.

Planting beans into dry soil and then irrigating it up can be a useful practice on soils that are high in clay content or on double-cropped plantings following cereals or other late-harvested crops. This method yields a time savings of 8 to 14 days, but it is more difficult than pre-irrigation. Dry beans that are irrigated up have more problems with seedling diseases, and weeds tend to be more of a problem because they germinate at the same time as the beans, making them more difficult to control. If you decide to use this method, you must not plant your beans more than 1 or 2 inches deep. Poor stands can result when beans are irrigated up if conditions are not ideal. All fields should be level to ensure uniform planting depth and to prevent ponding of irrigation water.

Weed Control

When you are establishing a dry bean crop, weed control is essential because common beans are not competitive with early emerging weeds. It is only after 30 to 40 days of growth that beans become competitive with late-emerging weeds, provided that stands are good. As a result, bean plantings require effective weed control, integrating cultural practices with the use of herbicides. Different dry bean classes have different levels of tolerance to herbicides, so the guidelines and recommendations in this section apply to common beans only. Other bean classes may be injured by these herbicides.

Since most common beans are planted in late spring, summer weeds and grasses are their major weed competitors. A number are especially troublesome, including hairy and black nightshade (*Solanum* spp.), groundcherry (*Physalis* spp.), yellow and purple nutsedge (*Cyperus* spp.), and barnyardgrass *(Echinochloa crus-galli).* Also challenging to manage are field bindweed *(Convolvulus arvensis),* annual morningglory (*Ipomoea* spp.), bermudagrass *(Cynodon dactylon),* velvetleaf *(Abutilon theophrasti),* and johnsongrass *(Sorghum halepense).* Where dry beans are double-cropped behind winter cereals, volunteer barley and wheat may also be of concern.

Weeds are problematic because they shade and crowd bean seedlings and compete for water and nutrients, causing a decline in stands and plant vigor with a potential yield loss of 10 to 50 percent. Weeds can also decrease the quality of dry beans. For example, nightshade and groundcherry berries produce a dark purple juice that can permanently stain beans, detracting from the visual appearance of the product. This is especially true for light-colored beans. Also, because nightshade berries contain poisonous alkaloids, there is zero tolerance for these berries in beans used for canning. Hand-weeding crews are sometimes needed to pull nightshade and carry it out of the field, which is costly to the grower. Grassy bean fields also attract armyworms, though they are normally not a problem in bean production. Barnyardgrass, with its fibrous root system typical of grasses, may make cutting and threshing at harvest more difficult.

To help control weeds, beans should be planted into moisture instead of irrigated up. This will help prevent weeds from germinating at the same time as the beans, and that will decrease costs for additional cultivation and hand-hoeing labor. Planting into moisture also allows for vigorous seedling development, which reduces the incidence of seedling diseases and makes the crop more competitive against weeds. Further, a 1- to 2-inch dry mulch of soil over the planted crop reduces weed seed germination until the first post-plant irrigation, by which time the crop is already established. Planting into moisture is most important for organic dry bean production, where it would be followed by cultivations for weed control.

Prior to planting, pre-emergence herbicides are broadcast-applied onto pre-formed beds and then incorporated to a depth of about 4 inches using a rolling cultivator (actual placement of herbicide will be half this depth, about 2 inches, with the beans planted below the treated zone). A tank mix of Treflan (trifluralin) and Dual Magnum (metolachlor) is often used: together these two chemicals provide broad-spectrum weed control. Treflan is active against most broadleaf and grass weeds but not against weeds in the nightshade family or nutsedge, whereas Dual is active against the nightshades as well as yellow nutsedge. Dry soils generally result in poor weed control with these pre-plant-incorporated herbicides, so make sure that adequate soil moisture is available for maximum efficacy.

Once the beans have germinated and before row closure, two mechanical cultivations are the usual practice for weed control, with one used to sidedress aqua ammonia into the beds. If weeds have escaped control and are problematic, postemergence herbicides are also available that do not cause injury to the bean crop. Poast (sethoxydim) and Select Max (clethodim) are effective against grass weeds. Both herbicides must be mixed with a crop-oil concentrate and the spray solution must be buffered if a high-pH or hard water is used. Pursuit (imazethapyr) can control many broadleaf weeds and several grass weeds and can also temporarily suppress nutsedge. To maximize herbicide performance, weeds must not be under moisture stress.

Cultivation

Cultivation in common beans generally serves to control weeds, to shape beds for cutting, and to improve furrow irrigation and aeration of the root system. This usually is done during the fertilizer sidedress operation. In general, cultivation after the beans have emerged does not conserve soil moisture and has the potential to cause severe root pruning if not carefully done. In cases where the soil seals badly after an irrigation or cracks across beds upon drying, a light cultivation may be beneficial. The dangers of root injury cannot be overemphasized, however, particularly as the bean plants get closer to flowering. Physical damage to plants during cultivation is another problem associated with excessive or unnecessary cultivations, as is soil compaction. "Throwing dirt" toward the emerged or established bean plants may bury some leaves, reducing their capacity to do the plants' work. Also, thrown dirt can pile fungus-infested soil against the plant stems, increasing the potential for disease problems. Tractor speed during cultivation must be monitored carefully to avoid injury to the dry bean crop.

Irrigation

Irrigation management is probably the most important factor influencing bean crop yield and quality in the Central Valley. The frequency of crop irrigation depends upon plant growth, root development, the water-holding capacity of the soil, and plant water use via evapotranspiration (ET). Daily weather and ET estimates, along with regular probe readings for soil moisture, are important for precise water management. Common bean types such as pink and kidney beans have relatively poor root systems compared to most other crops. Blackeyes have the best root systems, while lima beans are intermediate in terms of rooting depth. In research plots at UC Davis, one month after planting (when visual signs of moisture stress were first noted) the bean plants removed about 50 percent of the available soil moisture from the 6- to 12-inch depth. At the 3-foot depth, only 10 percent of the available moisture was removed.

Research and production experience have shown that common beans grown in the San Joaquin and Sacramento Valleys on loamy soils will require irrigation every 6 to 8 days. The most practical way to describe common bean irrigation is "frequent but light." Consumptive water use (evapotranspiration) of common beans ranges from 20 to 25 inches per season, depending upon the variety and production area. Consumptive use is the amount of water that evaporates from the soil plus the amount transpired by the bean plants. It does not include the loss of water from head-

ditch seepage and evaporation or the tail-water loss. Therefore, depending upon the efficiency of your irrigation system, the amount of water you apply may range from 25 inches to as much as 40 inches per year, plus an additional 6 acre-inches for the pre-plant irrigation.

Common beans are irrigated in a number of ways in California. Furrow irrigation is the usual method, but sprinklers are popular in some areas of the state, especially on shallow soils or soils high in clay content. Some beans are sub-irrigated, especially in the Sutter Basin of the Sacramento Valley. However, because common beans have a poor root system, this is a less common practice than with limas. Beans should be irrigated according to soil conditions and weather conditions rather than on observable symptoms of plant stress.

When soil moisture is low enough to limit rapid crop growth, plant color begins to darken. When water is applied, the canopy rapidly changes back to a lighter color. Canopy color differences between moisture-stressed and well-irrigated fields or sections of fields are easy to recognize. If bean plants are moisture-stressed to the degree that the plants turn a dark bluish green, you can expect lower leaves to begin to senesce and flowers and small pods to drop. If common beans are severely water stressed during the growing season, they will produce lower yields and poorer-quality beans because the weakened plants may not be able to recover from disease problems and physical damage caused by a temporary lack of water.

Irrigating Problem Soils

Furrow irrigation can easily saturate soils that are high in clay content and create an environment unsuitable for bean roots. Fungi such as *Rhizoctonia, Fusarium,* and *Pythium* will often infect bean roots in wet soils and may reduce stands, plant vigor, and yield. You can use sprinkler irrigation on high-clay soils in order to avoid root disease problems, though this may increase bean production costs and the potential for foliar disease problems.

Another approach to irrigating on clay soils is to use a wide bed with furrows formed on 60-inch centers as opposed to the conventional 30-inch beds. Shape the beds to be flat on top and plant the beans in two rows 26 inches apart. Irrigation runs should be 600 to 800 feet long, if possible, and in any case no longer than 1,200 feet. This system leaves an area between the rows on the wider beds unsaturated, thus maintaining an area in the soil where oxygen can remain available for the roots. This wide-bed system has no practical application on loamy soils and should not be used on silty soils with water-penetration problems. Furrow irrigation must be applied carefully on 60-inch beds to get good moisture penetration to the entire root system without waterlogging. On 30-inch beds, some growers irrigate every other row, alternating the furrows irrigated at each irrigation to manage water better on heavy soils.

Soils with high silt content present a challenge when you are growing common beans. These soils absorb moisture well after a cultivation, but after silty soils are irrigated a couple of times, they seal and become almost impervious to water penetration. After the bean plants mature and close in the row, cultivating equipment cannot be driven between the rows.

Diseases

There are a number of serious diseases that affect both common dry bean yield and quality in California and potential markets for the seed production industry. Seedborne diseases include bean common mosaic virus (BCMV) and bacterial blights. Soilborne diseases include the seedling diseases (*Rhizoctonia* and *Pythium*), *Fusarium* root or dry rot, white mold, and charcoal rot or ashy stem blight. Many of the diseases described in this section are best managed through variety selection and cultural practices, areas that are particularly important if you are an organic producer.

Bean Common Mosaic Virus (BCMV)

BCMV generally is introduced into the crop as a seedborne disease and is then spread by aphids. Disease severity depends on the virus strain, how much of the planting seed is initially infected, how old the plants are when the infection is spreading, aphid population size, and susceptibility of the planted cultivar. Visible symptoms generally take the form of light and dark green mottled or mosaic patterns on leaves. Other symptoms are leaf cupping with the edges curled downward, leaves that are smaller than normal, and plants that are stunted, with deformed blossoms and pods. Control of BCMV is easy: you just plant certified seed and use resistant varieties, which now exist for most

common bean market classes (see Table 2). Control of the aphid vectors with insecticides is not an economically viable approach to preventing BCMV.

Common and Halo Bacterial Blights *(Xanthomonas campestris, Pseudomonas syringae)*

Blights in dry beans are favored by conditions of high moisture and humidity. This makes the diseases fairly uncommon in California, but they are sometimes found in bean fields under sprinkler irrigation. Symptoms appear as brown spots surrounded by light green to yellow rings around leaf edges or in interveinal areas. Under severe disease pressure, the plant may lose its leaves and pods, and seeds may become infected, causing seeds to shrivel and to germinate poorly. To control these diseases it is important that you plant certified disease-free seed and practice a 2- to 3-year crop rotation. In addition, when you are growing dry beans for seed, it is important that you grow the crop under furrow or drip irrigation to guarantee that the seed is free of common and halo blights.

Seedling Diseases (*Rhizoctonia solani* and *Pythium* spp.)

Rhizoctonia solani is a fungus that often is the cause of postemergence dieback of seedlings. Commonly referred to as root or stem rot, stem canker, hollow stem, or damping-off, symptoms of this pathogen include reddish brown sunken lesions of varying sizes on the germinating seedlings and roots of infected plants. The lesions have well-defined borders that become rough, dry, and pithy as they age. The disease may spread to nearby plants that may not die, but often will give reduced yields. Branches and pods resting on the soil may also become infected.

Pythium, a water-loving mold, usually causes pre-emergence rot and dieback of seedlings. Initial symptoms include elongated water-soaked areas on the lower hypocotyl or roots of seedlings. The lesions turn tan to light brown and may become slightly sunken. Under wet conditions and warm to high air temperatures, the fungus may spread upward to other parts of the plant.

Most dry bean seed now comes pre-treated with fungicides such as Apron XL and Maxim to help control seedling diseases. In addition, as warm-season crops, common beans should be planted from mid-May to early July when soils and ambient temperatures are warm enough to favor rapid seed germination and emergence from the soil to help minimize seedling diseases. Other methods for preventing seedling diseases include the use of certified seed, making sure not to plant too deep (something that may occur when the grower is chasing moisture into the soil or when planting on uneven beds), and having good soil aeration.

Fusarium Root or Dry Rot *(F. solani)*

Fusarium is a fungal disease that is one of the causes of early maturity (also known as *early cut-out*) and marked reduction in yield. The first symptom is a slightly reddish coloration of the taproot that becomes apparent about a week after seedling emergence. As the disease progresses, it eventually covers the entire taproot, extending nearly to the soil surface but rarely above it. As the infection ages, reddened areas take on a brownish discoloration, frequently with longitudinal fissures in the diseased tissue. The root and lower part of the stem may become pithy. Severely affected plants that are stressed by drought conditions or excessive soil saturation will often show leaf yellowing. If conditions for *Fusarium* root rot (which occur early in the development of bean plants) are not corrected, plant growth at blossom initiation usually ceases or is greatly reduced. Small plants with yellowing lower leaves, early leaf drop and plant maturity, and low yields are all the result of infected roots that are incapable of providing adequate water at times of high demand.

Control measures for *Fusarium* root rot include crop rotation (6 to 8 years between bean crops), planting tolerant varieties, use of seed treatments with effective fungicides, and planting into warm, uncompacted soils. Soil compaction resulting from seed furrow openers may impede rapid root development and accentuate the disease problem. Management practices that avoid prolonged flooding or water stress and improve soil aeration and root growth in the dry bean crop will tend to reduce the effects of *Fusarium* root rot.

White Mold (*Sclerotinia sclerotiorum* and *S. trifoliorum*)

White mold is a fungal disease that is favored by moderate to cool temperatures, high moisture (humidity or rainfall), and aging plant tissue. In the Central Valley, the disease is generally observed

in late-planted, full-season dry bean varieties that mature in late September and into October. The disease starts from sclerotia—black, irregularly shaped structures of condensed mycelium that are resistant to decay and allow the fungus to survive in soil during periods of unfavorable conditions. When moisture is present these sclerotia germinate, producing airborne spores. In a moist canopy, the spores germinate in a water film on plant parts and develop infective white mycelium, fine strands of the fungus. Any part of the plant can become infected.

Symptoms are water-soaked lesions followed by a white, moldy growth on leaves, stems, or pods. As the infected part ages, it takes on a bleached or chalky appearance. Within a few days after the disease establishes, black sclerotia of varying sizes and shapes are formed on and in infected tissue. By using varieties with upright growth habit, a wider row spacing, or crop rotation away from susceptible crops, you may be able to help to reduce white mold infection. You need to monitor the crop carefully for white mold and be prepared to apply a fungicide, such as Endura (boscalid), on short notice. Careful late-season irrigation management is also important to limiting the disease. This includes keeping track of the weather and scheduling irrigations only when needed, and being very stingy with the water to avoid over-irrigation or standing water in the furrows. This is especially important at night, when temperatures are cool and there is no evapotranspiration and plenty of moisture in the canopy, conditions that favor disease development.

Charcoal Rot or Ashy Stem Blight (*Macrophomina phaseolina)*

Macrophomina is a fungal disease that is both soilborne and seedborne. In seedlings, symptoms include a conspicuous black sunken canker that appears near the base of the cotyledon and spreads downward into the stem and first pair of leaves. As the disease progresses, lesions begin at or below the soil level and extend downward into the roots, causing them to turn black, and often some distance upward into the branches. Lesions are somewhat sunken and reddish brown. The older the stem is when attacked, the more shallow the canker will be. As lesions enlarge they turn gray, and minute but distinct black fruiting bodies form in the center of the lesions. Many infected plants are either killed without producing seed or stunted, with reduced yield.

The fungus is pathogenic on many crops, including corn and sorghum, and the disease tends to be worse on certain soils. This disease occurs primarily under conditions of drought stress and high temperatures, especially when a late irrigation is applied. Avoid drought stress by applying frequent, light irrigations before serious crop stress occurs, especially during periods of high temperature. A 3-year rotation with a cereal crop also will help reduce soil disease inoculum.

Insects and Spider Mites

The primary pests of common beans are lygus bugs, summer worms, and spider mites. Other insect pests include aphids, wireworms, seedcorn maggots, and leafhoppers. Usually damage from these pests can be prevented if bean fields are inspected regularly and control programs used when damaging pest populations occur. As in most field crops, it is important to delay insecticide applications as far into the bean crop season as possible to avoid disruption of beneficial insect populations. Regular monitoring is effective in meeting this objective. For information on pesticides available for dry bean production, see the University of California Integrated Pest Management guidelines for dry beans at http://ipm.ucdavis.edu/PMG/selectnewpest.beans.html.

Lygus Bugs (*L. hesperus* and *L. elisus*)

Adults and older nymphal stages of lygus bugs damage beans by feeding upon buds, flowers, and young, developing pods with piercing, sucking mouthparts. If lygus bug populations are high, their feeding on flower buds and flowers can reduce yields as they destroy these reproductive parts. Lygus bug feeding upon developing pods results in shriveled, distorted, irregularly shaped seed, and unattractive spotting, particularly on light-colored beans.

Common beans are not preferred targets of lygus. Most common bean grain classes show limited yield or quality problems from lygus, compared to blackeye cowpeas and lima beans. Seed damage to light-colored varieties is the most common problem, and regular monitoring allows you to apply treatment in plenty of time to eliminate this risk. Adjacent safflower and alfalfa fields are likely sources of large lygus populations at bean flowering and so should be avoided, especially if you are growing organic dry beans. Common mustard *(Sinapis arvensis),* black mustard *(Brassica nigra),* and wild radish *(Raphanus*

sativus) also serve as sources of lygus, so you should take steps to control these plants around fields or replace them with vegetation that is not attractive to lygus (such as native grasses).

Monitor lygus bug populations weekly, beginning at the early floral bud stage, using a standard insect sweep net. Take a series of five to ten 180° sweeps in six areas of the field. Pass the net through the top of two rows of bean plants (one bed for double-row plantings or two beds for single-row plantings). The lygus threshold for common beans is 1.0 to 1.5 bugs (adults plus nymphs) per sweep.

Corn Earworm *(Helicoverpa zea)* and Armyworm (*Spodoptera exigua* and *S. praefica*)

The larvae of corn earworm and armyworm feed on leaves, buds, and flowers, and within pods, causing seed damage and yield losses. They are most abundant during the summer months, primarily July to September. To monitor for corn earworm, inspect the sweep net for small worms when sampling for lygus. Although sweeping is not an effective sampling method, the presence of small worms in the net indicates that a problem may be developing. Beating and inspecting for worms in pans or sheets is another alternative.

No precise economic threshold has been established for when to initiate control of corn earworm or armyworm on dry beans. However, it is a good idea to begin treatment when small worms appear in the sweep net and are found on young pods generally throughout the field.

Spider Mites (*Tetranychus* spp.)

Spider mites can cause leaf defoliation and significant yield reductions in common dry beans. In the spring spider mites move up from the soil, infesting the lower leaves and then migrating throughout the plant as it grows. The spread of mites is most severe near field edges where equipment traffic and dust are significant contributors to mite problems. This being the case, it is important to water the roads to keep dust down, especially in organic production. Early season pyrethroid insecticide applications used to control lygus or occasional seedling insects such as cucumber beetles *(Diabrotica)* or thrips *(Frankliniella occidentalis)* only tend to aggravate spider mite problems.

Spider mite colonies can first be found in low numbers on the underside of lower leaves close to the midrib vein. Look for pinpoint-sized whitish dots on the upper surface of leaves as an indication that there is a spider mite colony on the lower surface. When abundant, spider mites give bean leaves a finely stippled appearance over the entire upper surface and a gray appearance on the underside due to profuse webbing.

Spider mites should be controlled with an *acaricide* (miticide) if you find them throughout the field at pre-bud to early flower stage. A later population can be treated with the first spray for lygus bug control. At any stage of growth, good coverage of the plants is essential to achieving effective long-season control with one pesticide application. Drop nozzles that cover the underside of the leaves have given consistently better results than sprays from above. Several new acaricides are currently being reviewed for California registration for use on beans and have shown excellent control results while being safer in the environment. Always check the pesticide label for specific instructions and for stipulations if plants are to be used for forage after harvest.

Aphids (most commonly bean aphid, *Aphis fabae*)

Feeding damage from aphids causes leaves to curl. Severe aphid pressure will eventually stunt the growth of plants. Aphids also excrete sticky honeydew that is colonized by a black sooty fungus, reducing the leaves' capacity for photosynthesis, and aphids can spread viral diseases such as BCMV. Aphid infestations usually are sporadically scattered around the field and often they are kept under control by beneficial insects such as ladybird beetles, lacewings, and syrphid flies. This being the case, monitor fields for both aphids and beneficial insects. If aphid infestations affect plant growth (particularly in seedling stands), treatment with a pesticide may be needed to prevent crop damage.

Wireworms (*Limonius* spp.)

Wireworms are the soil-dwelling larvae of adult click beetles. The larvae injure crops by feeding on seeds in the soil, preventing seedling emergence. They also cut off small underground stems and roots and bore into larger stems and roots, affecting plant growth. Wireworms are commonly found in fields where the previous crop was pasture or weedy alfalfa. Avoid planting dry beans into fields infested with wireworms. This information should be known based on pest monitoring for previous crops.

Seed Corn Maggot *(D. platura)*

The seed corn maggot is the larval stage of a small fly that lays its eggs in soil. The larvae feed on germinating seeds and seedlings and damage the cotyledons and shoots of developing seedlings, causing severe stand reductions some years. Seed corn maggot is especially problematic in early spring plantings in damp soils and where weed or cover crop matter is decomposing. To control seed corn maggot, avoid fields with fresh decomposing organic materials and plant under ideal soil and weather conditions to ensure rapid seed germination.

Leafhoppers (*Empoasca* spp.)

Leafhoppers can seriously damage bean plants if they are not controlled, but severe leafhopper problems are rare in California. Where leafhoppers are abundant, leaves become tip-burned, turn yellow, and cup or curl downward. Heavily infested plants become stunted and bushy and set little or no seed.

Nematodes

All common beans are susceptible to root-knot nematodes (*Meloidogyne* spp.), especially when grown in coarse-textured soils. Root-knot nematodes are microscopic roundworms that feed on the plants' roots, creating galls and cause the plants to become chlorotic, stunted, necrotic, or wilted. In general, although common beans grown on silt loam to clay loam soils can show some plant damage, they are not as heavily infested with root-knot nematodes as plants on coarser soils. Root-knot nematodes tend to reproduce more rapidly and build to higher populations on coarse-textured soils. Beans should be grown in rotation with a nematode-resistant crop (such as a cereal) or at least a crop that minimizes nematode buildup. Nematicide applications are too expensive to make economic sense for common bean production.

Harvesting

Common bean harvesting in California consists of cutting, windrowing, and threshing the crop, a process that requires specialized equipment. Weather conditions need to be monitored carefully during each harvesting step to try to avoid high, drying winds (to prevent shattering) or rains. Common beans may be grown as a single crop per field per year, but much of California's kidney and pink bean acreage is double-cropped after wheat or barley. Harvest for double-cropped beans occurs in October, and often into November when rainfall is more of a risk.

Cutting

Most common beans should be cut when the moisture of the beans is at 50 percent. In the field you can see that they have reached 50 percent when 20 percent of the pods are green, 30 percent are yellow, and about 50 percent are tan colored. At this stage, about 5 percent of the beans from the pods will be green, 75 percent will be colored but soft, and 20 percent will have the appearance of dry beans. Bean plants are cut 2 to 3 inches below ground level with a set of tractor-mounted knives. Most knives are about 5 feet long. Guide rods attached above the knives move two rows of beans together as they are cut. Six-row cutters are commonly used, generally in the same configuration used for field preparation and planting. Vertically oriented cutting sickle knives are required for vine beans, but not for bush varieties.

Windrowing

The bean windrower usually picks up six rows (three sets of two rows each) and moves them into a single windrow. Sometimes beans are windrowed directly behind the cutters, but more often this operation is performed a day or more later, depending upon the condition of the plants when cut, bean moisture, air temperature and humidity, and the time of year. As a general rule, beans cut in August or September will be windrowed quickly and only at night or early in the morning to avoid pod shattering, bean shrinkage, and sunburn. Beans cut in October may not be windrowed for several days, especially if the weather is cool and the plants are still leafy. Regular monitoring of weather reports and careful planning are critical, as rain on the cut or windrowed crop can cause severe reductions in bean quality, while low-humidity winds common in the fall can cause pod opening and seed loss. If windrowed beans are rained on, you can use a side-delivery rake to turn the windrow after the ground surface dries, in an attempt to promote drying to avoid mold and discolored beans.

Threshing

Most common beans are threshed using specially designed bean threshers equipped with two or three slow-turning cylinders. In contrast to bean production areas in the eastern United States, California beans have dry pods and beans and

relatively green stems at harvest. The two-and three-cylinder threshers can separate the pods and plant material (chaff) from the dry beans with very little damage to the beans.

Care must be taken in threshing beans because moisture in the seed can drop very quickly in the windrow to 8 or 9 percent, especially when the beans are cut in August and September. At such low moisture levels, beans become too brittle and are easily damaged during threshing and handling. Threshing should be done when the beans in the windrow contain between 12 and 15 percent moisture. This is determined using a seed moisture meter, generally after beans have been collected from a short trial harvest run. Thresher operators must be very aware of moisture and relative humidity changes during the day. A small change in threshing humidity can result in significant effects on recovery and seed damage. Experienced harvesters often thresh only for the few hours each day when relative humidity and seed moisture are optimal.

Beans are handled in bulk in most California production regions. From the thresher, the beans are transferred into trucks or trailers for transport to the warehouse. At the warehouse, beans are dumped from the back of truck beds with hydraulic lifts or from bottom-dump trailers into pits. Extreme care should be exercised in all bean-handling operations from threshing to cleaning, because damage to the beans is cumulative. "Cryptic" (non-visible) damage to bean seeds has been shown to negatively affect germination, seedling vigor, and cooking characteristics. It is important to keep in mind that the beans' visual appearance is perhaps the most important determinant affecting the price you will get for your crop. Beans grown as planting stock must be threshed and handled with even greater care to avoid damage that will affect seed germination and vigor.

Cleaning, Grading, and Marketing

Dry beans from the thresher often contain 5 to 30 percent "dirt," consisting of plant debris, small rocks and clods, bean pieces, and other foreign matter. Such debris, along with diseased, discolored, broken, split, and insect-damaged beans, must be removed. At the warehouse, the beans are weighed, tested for moisture, and assigned a lot number. A subsample from each truckload is taken for future reference to that particular load. Beans are then dumped into a conveyor pit and run through a "scalper" to remove most of the large and fine extraneous materials en route to bins where the beans are stored until they can be re-cleaned.

Beans are mechanically separated from debris during cleaning, usually by an air-screen separator, gravity tables, de-stoners, aspirators, and in some cases textured rice rollers. Beans may be sorted for size during the screening process. Beans destined for retail packaging are often polished in commercial polishing machines to remove fine dust and other imperfections from the bean surface. Beans destined for the canning industry typically are not polished. Beans in the warehouse are usually re-cleaned on a first-come, first-served basis. Most California warehouses today use electronic color sorters to remove discolored beans and other contaminants that are not easily removed with traditional mechanical cleaning systems. Beans are typically packaged in 50- or 100-lb bags and put on pallets for shipment, or packaged in 2,000-lb totes that can be loaded directly onto trucks without palletization. The warehouse manager may serve as the broker or as an intermediary between the grower and the broker for sales of dry beans.

Grading of common beans to meet federal grading standards may or may not be necessary to make a sale. If it is required, impartial representatives of the USDA Agricultural Marketing Service will sample and grade the beans. There are three distinct destination markets for California beans: the canning industry, the retail packaging industry, and international export (primarily to Japan, Mexico, Canada, and the United Kingdom). Most common beans are grown under contract to processors and for package or bulk sales. A significant amount of California common bean acreage today is for seed stock for export to other states.

Additional Reading

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USDA–NASS. US Department of Agriculture National Agricultural Statistics Service. Available online at http://www.nass.usda.gov/

UC IPM. University of California Integrated Pest Management Guidelines for Dry Beans. Available online at http://www.ipm.ucdavis.edu/PMG/selectnewpest.beans.html

WARNING ON THE USE OF CHEMICALS

Pesticides are poisonous. Always read and carefully follow all precautions and safety recommendations given on the container label. Store all chemicals in their original labeled containers in a locked cabinet or shed, away from foods or feeds, and out of the reach of children, unauthorized persons, pets, and livestock.

Recommendations are based on the best information currently available, and treatments based on them should not leave residues exceeding the tolerance established for any particular chemical. Confine chemicals to the area being treated. THE GROWER IS LEGALLY RESPONSIBLE for residues on the grower's crops as well as for problems caused by drift from the grower's property to other properties or crops.

Consult your county agricultural commissioner for correct methods of disposing of leftover spray materials and empty containers. **Never burn pesticide containers.**

PHYTOTOXICITY: Certain chemicals may cause plant injury if used at the wrong stage of plant development or when temperatures are too high. Injury may also result from excessive amounts or the wrong formulation or from mixing incompatible materials. Inert ingredients, such as wetters, spreaders, emulsifiers, diluents, and solvents, can cause plant injury. Since formulations are often changed by manufacturers, it is possible that plant injury may occur, even though no injury was noted in previous seasons.

For More Information

You will find related information in these titles and in other publications, slide sets, CD-ROMs, and videos from UC ANR:

Blackeye Bean Production in California, Publication 21518
Color Photo Guide to Dry Bean Pests, Publication 3329PS2
Dry Beans: UC IPM Pest Management Guidelines, Publication 3446

To order these products, visit our online catalog at http://anrcatalog.ucdavis.edu. You can also place orders by mail, phone, or FAX, or request a printed catalog of publications, slide sets, CD-ROMs, and videos from

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