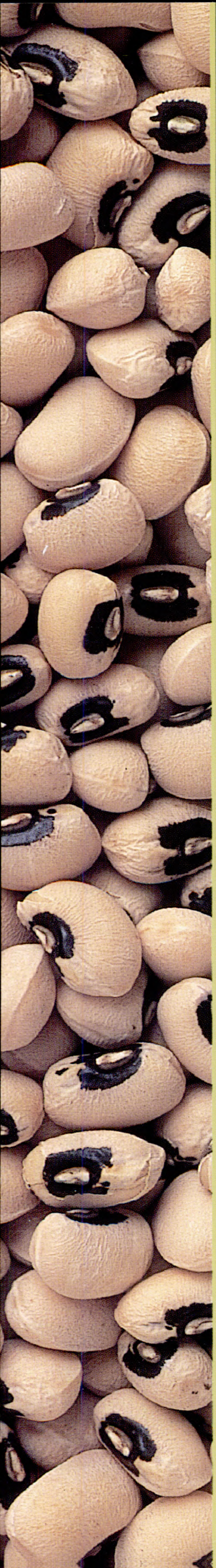

BLACKEYE BEAN

PRODUCTION IN CALIFORNIA

UNIVERSITY OF CALIFORNIA
DIVISION OF AGRICULTURE AND NATURAL RESOURCES
PUBLICATION 21518

For information about ordering this publication, contact

Communication Services
Division of Agriculture and Natural Resources
University of California
6701 San Pablo Avenue
Oakland, California 94608-1239

Telephone (510) 642-2431
within California (800) 994-8849
FAX (510) 643-5470
e-mail inquiries to anrpubs@ucdavis.edu

Publication 21518

Printed in the United States of America.

3m-pr-1/96-WJC/VFG

printed on recycled paper.

The technical editors are
Anthony E. Hall,
Crop Ecologist, UC Riverside,
and Carol A. Frate,
UC Cooperative Extension Farm Advisor, Tulare County.

In addition to the technical editors, other contributing authors are
David Billings,
President, Marketing Cooperative, Ventura;
David W. Cudney,
Extension Weed Scientist, UC Riverside;
Donald C. Erwin,
Plant Pathologist, UC Riverside;
Peter B. Goodell,
Regional IPM Advisor, Kearney Agricultural Center, Parlier;
Dard Hunter,
Bean Dealer, San Francisco;
Jerry Munson,
Manager, California Dry Bean Advisory Board;
Phillip P. Osterli,
UC Cooperative Extension Farm Advisor, Stanislaus County; and
Philip A. Roberts,
Nematologist, UC Riverside.

The manuscript was reviewed by
Jim Andreas,
Farmer, Delano;
Don Cameron,
Warehouse Manager, Pixley;
Jeffrey D. Ehlers,
Research Specialist, UC Riverside;
Richard O. Hampton,
Virologist (USDA), Oregon State University, Corvallis;
Shannon Mueller,
UC Cooperative Extension Farm Advisor, Fresno County;
Blake Sanden,
UC Cooperative Extension Farm Advisor, Kern County;
Charles G. Summers,
Entomologist, UC Berkeley; and
Steven R. Temple,
Extension Agronomist, UC Davis.

Blackeye Bean Production in California

Anthony E. Hall and Carol A. Frate, technical editors

The blackeye bean (*Vigna unguiculata* [formerly *V. sinensis*], fig.1) is the main type of cowpea grown in California. The produce is sold as dry blackeye beans, also known as blackeye peas in the southern United States. Some southern pea varieties of cowpea are grown in small plantings in California, including Coronet, Pinkeye Purplehull-BVR, Mississippi Silver, Clemson Purplehull, and Queen Anne. These southern peas are grown either for seed for the southern United States or for use as fresh-shelled peas, typically in "U-Pick" operations. Blackeye bean varieties also are suitable for use as fresh-shelled peas, provided they are picked at color-break when pods first become yellow. There are also small plantings of edible-pod cowpea varieties, including Chinese yard-long beans (*Vigna unguiculata*, also called *V. sesquipedalis* in earlier years), which are climbing varieties, and bush types that have been developed for California by UC Riverside researchers. In the past, specific cowpea varieties were grown in the United States as hay, forage, or green manure crops, but no varieties adapted for these uses have been developed for California. This publication focuses on dry blackeye bean production, but many of the recommendations concerning growing conditions and cultural practices also apply to southern pea, forage, and edible-pod varieties, except that Chinese yard-long beans are grown on trellises.

The first record of cowpea planting in the American colonies is from 1707. In 1940, more than 5 million acres were planted in the United States. Most of the cowpeas were grown for hay, but 1.4 million acres, mainly in the southeastern United States, Texas, and California, produced southern peas and dry beans for human consumption. Since 1940, the area sown to cowpeas has decreased substantially in the southeastern United States and Texas. Out of about 100,000 acres currently planted, most are in southern pea varieties, with a variable acreage of blackeye beans in Texas.

Figure1. Blackeye beans 10 weeks after sowing.

Commercial production of blackeye beans was first reported in California in 1880. Since the early 1900s the total planted area has remained relatively constant at 40,000 to 60,000 acres, but the area of production has shifted from more northerly locations and Riverside County to the southern San Joaquin Valley. The decline in cowpea production in the southeastern United States and Texas indicates that the survival and continued health of the blackeye bean industry in California cannot be taken for granted. A concerted, cooperative effort on the part of growers, farm advisors, scientists, grower organizations, and commercial organizations involved in production and marketing is needed to develop more efficient and environmentally sound produc-

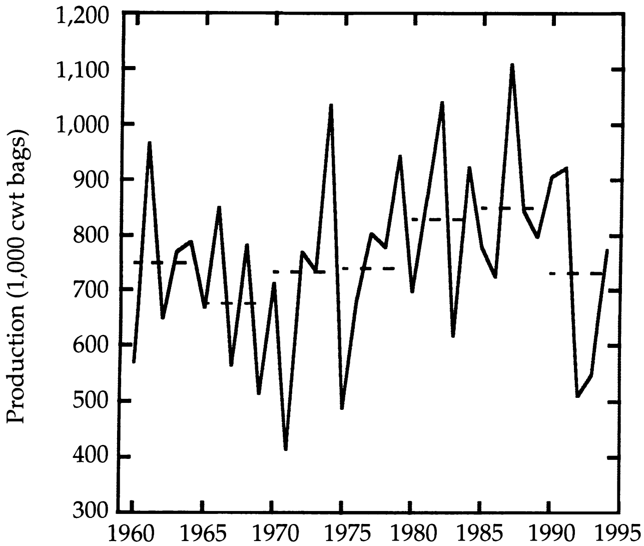

Figure 2. Total annual California production of blackeye beans with 5-year averages shown as broken lines.

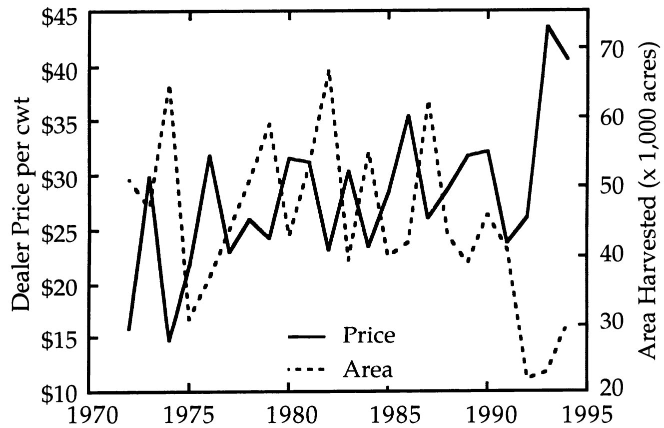

Figure 3. California average dealer price (yearly average of monthly mean values) for blackeye beans (*solid line*) and total area harvested (*broken line*).

tion methods and to expand market opportunities for blackeye beans and other cowpeas.

Production Statistics for California

The average production of blackeye beans in California between 1960 and 1994 was 756,000 hundredweight (cwt) bags per year, with higher production in the 1980s of 839,000 bags (fig. 2). Production exceeded 1 million bags in 1974, 1982, and 1987, due mainly to increases in area planted. About 65,000 acres were planted in these three years, compared with a 30-year average area of 50,500 acres between 1960 and 1989. In years when greater acreages were planted and harvested, prices received for blackeye beans were relatively low (fig. 3). Demand for blackeye beans appears to be relatively constant, and a moderate increase (14,500 acres) in planted area can increase production sufficiently to depress prices. Large carryovers of blackeye beans from the previous year may also help depress prices. Large-planting years tended to follow years with above-average prices for blackeye beans (fig. 3). The record dealer price of $43.50 per cwt in 1993–94 (fig. 3) followed two years with small harvested areas and poor production (fig. 2). The balance of supply and demand is also influenced by the size and quality of the crop produced in Texas.

The Blackeye Varietal Council of the California Dry Bean Advisory Board has closely monitored the carryover, crop size, and shipments of blackeye beans (both foreign and domestic) since 1975. The Dry Bean Advisory Board publishes information about the blackeye bean crop size and inventory quarterly in *The Bean Marketer,* which is sent to all bean growers in the state. This information is used by the Council's promotion program, which attempts to counteract the effects of oversupply by promoting sales more aggressively in years with high production. The promotion program has the additional objective of gradually increasing domestic and overseas markets for blackeye beans. Statistical information on carryover, crop size, and shipments can help growers avoid the overplantings that result in catastrophic price reductions. New growers of blackeye beans are advised to not try large experimental plantings. From an agronomic point of view, they should plant only small areas until they have gained the experience required to grow a productive, high-quality crop of blackeye beans.

The economic health of the blackeye bean industry in California will depend to a large degree upon its ability to improve production efficiency. Yield per acre is a major factor in production efficiency, and management methods and bean varieties that require fewer inputs per acre can contribute to profitability. Growers have achieved substantial increases in productivity since 1970 (fig. 4), presumably as a consequence of the adoption of improved management methods and new varieties. New varieties released by UC Davis in 1987 (CB46) and 1989 (CB88) have produced consistently higher yields in trials than CB5 or the old wilt-resistant variety CB3 (table 1), and are being adopted by growers. In 1991, 63 percent out of 16,000 cwt of seed dispensed by warehouses was CB46, 35 percent was CB5, and 2 percent was CB88. In 1995, 66 percent of seed dispensed by warehouses was CB46, 18 percent was CB5, and 16 percent was CB88.

Blackeye Bean Growth and Development

Climate

Blackeye beans are well adapted to the late spring and summer growing conditions of California's Central Valley. At planting, they require warm soil with average temperatures in the seed zone of at least 66°F (19°C) for at least three days after sowing, or plant emergence will be delayed and reduced. Earliest effective planting dates range from early April for hot spring conditions in Kern County to early June for cooler years and locations such as Stanislaus County. Early plantings should be made only when clear skies and warm weather are forecast for the few days immediately after planting. Blackeye beans require warmer soils for effective emergence than some other warm-season crops, such as corn or cotton. It is often advantageous to plant blackeye beans as soon as it is warm enough, since this enables the crop to set the first and major flush of pods before the hottest summer weather, which typically occurs in late July and early August.

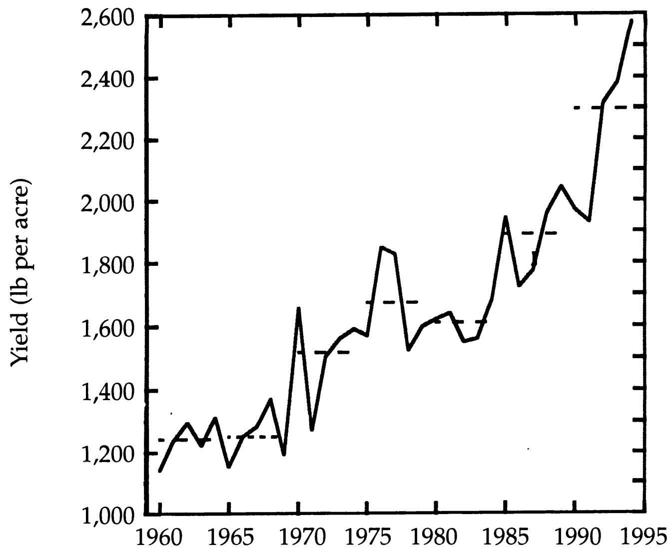

Figure 4. California annual average yield of blackeye beans, with 5-year averages shown as broken lines.

Also, late June or July plantings run the risk of fall rain damage after cutting, when the crop is in the windrow.

Under optimal soil conditions, blackeye beans emerge 3 to 5 days after planting. Under cool soil conditions, they may take as long as 10 days to emerge, seedlings may be lost to diseases, and leaf growth may be stunted or distorted due to thrips. If the stand is sparse, the grower must decide whether replanting is necessary. This is a difficult decision: with a typical sowing rate of four seeds per foot of row, a plant stand as low as 50 percent can be

Table 1. Blackeye bean varieties bred for California

Variety	Year*	Reaction to: Fusarium†	Reaction to: Root-knot‡	Growth habit	Maturity§	Seed weight¶	Seed per lb#	Relative bean yield**
CB88	1991	resistant	resistant	upright vigorous	90	21	1,940	115
CB46	1989	resistant	resistant	upright compact	90	20	2,040	111
CB5	1940s	susceptible	resistant	upright vigorous	90	23	1,770	100
CB3	1960s	resistant	susceptible	lodges	97	22	1,850	85

* First year when more than 1% of area was planted to this variety

† Fusarium wilt (*Fusarium oxysporum* f. sp. *tracheiphilum* race 3)

‡ Root knot nematode (*Meloidogyne incognita* races 1 and 3)

§ Minimal period from planting to cutting of the first main flush of pods in days; with cooler conditions this period can be up to 15 days longer

¶ Average dry weight in grams of 100 seed when grown at Kearney Agricultural Center near Fresno

\# Average number of seeds per pound at 10% moisture content when grown at Kearney Agricultural Center near Fresno

** Average main flush yield on fields at the Kearney Agricultural Center and West Side Research and Extension Center, which did not have obvious levels of Fusarium wilt, as a percentage in relation to CB5 tolerated, provided that plants are evenly distributed in the field. With 30-inch rows, vigorous blackeye bean plants spaced 12 inches apart can spread enough to produce the same yields as plants spaced 3 inches apart. Replanting not only involves additional costs; it also results in later planting, which increases the risk of lower yields due to hot weather at flowering and increases the risk of rain damage after cutting.

Vegetative growth is slow for the first 2 to 3 weeks after emergence, and then growth is rapid. The first floral buds are produced on the third or fourth node on the main stem (the first node is the position where the first trifoliate leaf is produced). Under cool conditions, the first floral bud can be seen fig. 5) about 50 days after planting, whereas under hot conditions plant development is more rapid and the first floral bud can be detected within 35 days of planting. Flowers are produced about 15 days after the first appearance of floral buds; consequently the first flowers are produced from 50 to 65 days after planting into moisture. Individual floral buds produce two or more pairs of flowers on each peduncle, with a delay of about 4 days between the appearance of the first and the second pairs. Plants continue to produce flowers on the main stem and branches for about 25 days. Planting dates, soil moisture, nutrition, and pest management should be designed to protect the first flush of floral buds, flowers, and pods. Effective management typically results in the four flowers on each peduncle producing two to three pods and yields of 25 to 35 cwt per acre from the first flush. Pod set can be reduced by heat stress, a common occurrence in the San Joaquin Valley during July and August. High night temperatures early in the flowering stage reduce pod set, with damage beginning when minimum nighttime temperatures exceed 63°F (17°C), and causing 50 percent reductions in pod set and yield when minimum night temperatures reach 80°F (27°C).

Figure 5. Floral buds on the main stem.

The development of individual pods from flower opening to mature dry pod takes from 17 to 21 days in California, depending upon night temperatures. Under hotter conditions, the pod-development period is shorter and smaller seed are produced (e.g., dry seed weight of CB5 can vary from 20 to 26 g per 100 seed; at 10 percent moisture content, that's from 2,040 to 1,570 seeds per pound). With optimal conditions eight seeds on average are produced per pod, even though individual pods can produce as many as fifteen seeds. Fields are cut to permit the plants to dry before threshing. To harvest for the first flush of pods, the field can be cut about 90 days after a late planting under hot conditions or 100 days after an early planting under cooler conditions.

Some growers manage the crop to accumulate a second flush of pods before cutting. When the first flush of flowers is complete, plants produce few or no flowers for about 15 days, and then a second flush of flowering begins. This second pod set can produce up to 20 cwt per acre depending upon the extent of the first pod set, the viability of plants at the end of the first pod set, and the subsequent growing conditions. Plants may begin to senesce at the end of the first flush of pods as a result of a heavy first pod set, drought, or various diseases. If more than 70 percent of the plants have died, the second flush of flowers and pods will be so small that it should be ignored and irrigation should be terminated. If the first flush of floral buds and flowers has been damaged by insect pests such as lygus bugs or by high night temperatures, most plants will be alive, and some yield compensation can be achieved with a second pod set. During the second flush, healthy plants produce abundant flowers for about 25 days, and individual pods require a further 20 days to reach maturity. Crops can be cut a few days before all pods achieve maturity, but by waiting to accumulate the second pod set a grower can delay cutting to about 140 days after planting. In the southern San Joaquin Valley, the season is sufficiently long to accumulate and harvest two flushes of pods, provided that the crop is planted early. Accumulating a second flush of pods is risky north of Fresno and with late planting in most areas, however, since rain can destroy a blackeye bean crop in windrows.

The most effective general management practice is to plant as soon as the weather is warm enough and to manage the crop for a heavy set (2 to 3 pods per peduncle) of well-filled pods (at least 8 seeds per pod) on the first flush of flowers. In some cases, irrigation is terminated after the first pod set, and the crop is cut. Where the first pod set is low or where the crop has the ability, growing conditions, and time to completely produce a substantial second flush, it can be worth the risk to extend the season with additional irrigations, but continued management of insect pests such as lygus bugs is necessary.

Soils

Adequate blackeye bean production is possible on many types of soil ranging from coarse sands to clay loams, provided irrigation is managed so that plants are neither water-stressed nor waterlogged. Blackeye beans are more sensitive to anaerobic conditions in the root zone than are many crops. Under saturated conditions, plants are stunted, root systems are small and prone to disease, and leaves may turn yellow from iron deficiency. Plants rapidly recover from this condition early in the season if the grower permits the root zone to become aerated by delaying irrigation or by switching to alternate-furrow irrigation. Where surface irrigation is used on soils with low permeability, land should be leveled sufficiently to minimize end-of-field waterlogging.

Blackeye beans have a moderate tolerance to salinity, with greater tolerance than corn but less than wheat, barley, sugarbeet, or cotton. Blackeye beans have exhibited no yield losses until salinity in the root zone has exceeded an electrical conductivity of 4.9 deciSiemens per meter (dS/m); for each increase of 1 dS/m above this threshold, yields were reduced by 12 percent. If sources of water with different salinity levels are available, it is preferable to develop a low salt condition during germination and early vegetative growth, when the crop is most sensitive to salinity, and then to apply the poorer-quality water during pod filling.

Blackeye beans are less tolerant to high boron levels than wheat, alfalfa, and potato, and much less tolerant than sugarbeet or cotton. Boron toxicity results in a distinctive necrosis along the edges of the leaves. Thousands of acres of blackeye beans have been destroyed at the seedling stage due to boron toxicity on the west side of the San Joaquin Valley. The threshold level for boron in the soil water above which yield losses have occurred with blackeye beans is 2.5 parts per million (ppm). At higher concentrations, yield losses were 11.5 percent for each ppm above 2.5.

Cropping Systems

Most blackeye beans are grown as a single crop and are harvested after producing one or two flushes of pods. In the southern San Joaquin Valley some blackeye beans are grown as a double crop, with late sowing in June or July after a wheat or barley crop has been harvested. Double crops usually are cut after producing one flush of pods, and tend to have lower yields than single crops. Small plantings of blackeye beans are grown as intercrops in almond orchards when the trees are still small.

In the rolling hill lands on the east side of the Valley in Stanislaus County, single crops of blackeye beans are grown in rotation with wheat under sprinkler irrigation. In contrast, in the adjacent level lands to the west, blackeye beans are often flood irrigated within borders and rotated with several different crops, including corn, winter forage mix, alfalfa, and the occasional field of sweet potato, squash, or watermelon. In Stanislaus County, blackeye beans are often planted flat with 30-inch rows and are cut with self-propelled swathers.

In the southern San Joaquin Valley, blackeye bean crops are often grown in rotation with cotton and several different crops, including corn, alfalfa, Sudangrass, and melons. Most of the planted area is on the east side of the valley, but some is on the west side, especially in Kern County. In these areas, blackeye beans are mainly grown on beds with surface irrigation, but some growers use overhead sprin-

Figure 6. Damage to floral buds caused by lygus bugs.

klers. Where cotton is a major crop in the farming system there is a tendency to grow blackeye beans on wide beds (38 inches is a common width), but most of the blackeye bean crop is currently grown on 30-inch beds.

Several general recommendations can be made concerning blackeye bean cropping systems. Progressive yield reductions can occur if blackeye beans are grown continuously on the same land. Growing blackeye beans every other year with small grains in the intervening year appears to be an effective way to maintain yields. Subsequent crops may benefit from having blackeye beans in the rotation. Present varieties of blackeye beans, with the exception of CB3, can suppress some biotypes of root-knot nematode that damage cotton. Blackeye beans enhance soil fertility through biological nitrogen fixation and root associations with mycorrhizae that enhance uptake of phosphate and zinc. Some adjacent crops can cause problems for blackeye beans. Alfalfa attracts lygus bugs, and if the whole alfalfa field is cut these bugs are driven out and can cause substantial damage to floral buds of blackeye beans in nearby fields (fig. 6). This problem can be partially avoided by strip-cutting alfalfa. Insect pest management of blackeye beans is complicated by the fact that alfalfa and cotton are alternate hosts to the two major insect pests of blackeye beans—lygus bugs and cowpea aphids. Cucurbit crops such as melons and squashes are alternate hosts to certain mosaic viruses and provide a reservoir for viruses that can then be transmitted to blackeye beans and cause damage.

Choice of Variety

Of the four varieties of blackeye beans available in California for dry bean production (table 1), CB46 and CB88 are recommended. A majority of the area planted in California in 1991 was sown to CB46. The only known limitations of this variety are that it is more compact than the older CB5 and that it does not suppress weeds as effectively, especially when grown on wide rows (e.g., 38 or 40 inches) and with sandy, infertile soils that do not support vigorous shoot growth. Also, CB46 has smaller seed than CB5 (table 1), and so may be less desirable for package and export markets. CB88 was developed to overcome these problems. It is more vigorous and has larger seed than CB46. Planting CB5 is not recommended, since it is susceptible to Fusarium wilt. Many fields used for blackeye bean production in California have at least low levels of the Fusarium wilt fungus, and continued use of CB5 will cause the disease level in the soil to increase and will encourage its spread to other fields. Planting CB3 is also not recommended despite its resistance to Fusarium wilt, since it has a lower yield potential than CB46 or CB88 and is susceptible to lodging and root-knot nematode. New varieties being developed by the University of California will have higher and more stable yields resulting from their heat tolerance, resistance to cowpea aphids and lygus bugs, and more complete resistance to Fusarium wilt and a range of root-knot nematodes.

Choice of Seed

The California Crop Improvement Association, in cooperation with the UC Davis Department of Agronomy and Range Science, maintains foundation seed for all dry bean varieties recommended for use in California. Foundation seed for blackeye bean varieties has high genetic purity and negligible levels of seedborne diseases. Under a certification program, growers can obtain foundation seed and plant it to produce registered seed. Under most conditions, this registered seed is used to produce certified seed, which is recommended for commercial production of dry beans. Seed should have a high germination percentage (e.g., ≥85 percent). Blackeye beans are highly self-pollinated, and natural hybridization leading to off-types is rare. Seed mixing is a potential problem and can occur in planters, threshers, or warehouses. Maintenance of varietal purity requires careful seed handling.

Cultural Practices

Land preparation

Seedbeds should be relatively free of clods, with no compaction zones that impede root or water penetration, and with 2 or 3 inches of dry soil on the surface and moist soil underneath. The operations needed to prepare a field vary depending upon soil type, soil moisture, and the previous cropping history and management. Residues from the preceding crop are either removed or incorporated into the soil; incorporation can improve soil structure and water-holding capacity. Incorporated residues may interfere with planting depending upon the amount of residue and type of planter. In compacted soils, chiseling to a depth of 12 to 14 inches can be beneficial, although growers often postpone chiseling until they plant a crop with a higher cash value than blackeye beans.

Fields are usually preirrigated either in flood basins or in furrows. Once fields have dried enough to support wheel traffic, final preparations are made. When planting flat, a light disking followed by a float is common. When planting on beds, the beds are lightly cultivated to kill any emerged weeds and then shaped. In all cases, excessive losses of soil moisture must be avoided so that seed can be planted into moist soil.

Fertilization practices

Nitrogen, phosphorus, and potassium applications have rarely affected blackeye bean yields in University of California field tests. Blackeye beans belong to the legume family, and have the ability to form an association with *Rhizobium* bacteria and produce nodules on their roots (figure 7) that fix nitrogen from the air. With *Rhizobium* bacteria either applied with seed or already in the soil, the crop usually has enough nitrogen. On rare occasions, a pre-sowing application of nitrogen may visibly increase growth and yields. Some growers apply "starter nitrogen" at rates of 40 to 60 pounds of nitrogen per acre to promote early growth, especially with the more compact CB46 variety. There is no documentation that this practice increases yields, but the larger canopy should compete more effectively with weeds. Layby applications of nitrogen at early flowering increased bean yields in some experiments but not in others. The conditions under which this practice would be effective are unknown.

Blackeye beans appear to be more efficient in the uptake of phosphate than cotton or corn, possibly due to root associations with fungi such as mycorrhizae. Trials under very low soil phosphate conditions did not show significant responses to phosphate fertilization. However, if soil phosphate is very low, phosphate fertilizer should be applied in order to start rebuilding the supply for future crops. When soil tests show the available phosphorus level to be below 5 ppm, at least 100 pounds of phosphorus per acre should be applied as P_2O_5.

Very few trials have been conducted on potassium fertilization in blackeye beans. Deficiencies are possible in sandy soils. If standard potassium soil tests show exchangeable potassium levels below 50 ppm or if previous crops have exhibited deficiency symptoms, potassium should be applied. Increased soil potassium levels can be useful for future crops, especially cotton.

Figure 7. Root nodules resulting from symbiotic association with *Rhizobium* spp.

Planting practices

Single rows on either 30-, 38-, or 40-inch beds are the most common spacings. The decision is usually based on the equipment available on a farm and the bed spacings used for other crops. With larger blackeye bean varieties such as CB88 or CB5, the slight advantage that the narrower row spacings may contribute to yield is not worth the inconvenience involved in adjusting equipment if all other crops are grown on wider beds.

With a variety like CB46 that tends to be smaller, there may be concern that significant yield reductions might occur on wider-spaced beds. In two years of trials at the UC Kearney Agricultural Center in Fresno County, no significant yield differences were detected between plots on 30- and 40-inch bed spacings. However, CB46 grew vigorously at this location, and even on 40-inch beds the plants covered the furrows. On soil types where CB46 tends to be small or when a delayed first irrigation severely stresses CB46, it is common for plants not to cover the furrows during the season. Although high yields have been obtained under these conditions, weed problems are greater because of the lack of crop competition in the furrow area. This can be harmful to crop quality if black nightshade, hairy nightshade, or ground cherry is present.

Some growers, particularly in Kern County, have been experimenting with two rows of CB46 on a 40-inch bed. In these cases, plants have covered the furrows and yields have been high. Results from two years of trials at the Kearney Agricultural Center have been inconclusive as to whether yields increase with this planting configuration. Longer knives are required to cut double rows on wide beds, so growers should not plant in this configuration unless they have made previous arrangements for cutting the crop.

Experiments with CB5 indicate that within-row average spacings of 4 to 12 inches do not alter yields. With more space between plants, the plants grow faster and larger, and this compensates for the reduced numbers. No detailed studies have been conducted with newer varieties, but it is probable that within-row spacings of 4 to 8 inches will not affect yields, even with the more compact CB46. Due to differences in seed size among varieties and even within a variety, no general recommendations can be given concerning how many pounds of seed should be planted per acre. Growers should try to plant four seeds per foot of row, and the equivalent pounds per acre will vary depending on seed size and seed density. Seed should be planted through the dry surface soil, 1½ to 2 inches deep in the moist soil below.

Seed treatment

Practically all blackeye bean seed is treated with fungicides to protect against seedling diseases. These diseases are more likely to occur when soil temperatures are cool and seedlings are growing slowly, but because the cost is small, seed treatment is regarded as relatively cheap insurance for all plantings.

In some cases seed are inoculated with *Rhizobium.* There are several formulations of rhizobial inoculant for blackeye beans. One formulation is the traditional one, in which bacteria are placed in a peat carrier. Packages of this type of inoculant need to be kept in cool but not freezing conditions until the contents are applied to seed. Once inoculated, seed should not be exposed to sunlight or hot conditions since this will kill the bacteria. Another formulation is a dry granule that is more tolerant to heat but requires a separate applicator box. Dry granules are more expensive than the peat-based inoculum. No comprehensive yield tests have been conducted to establish the value of different inoculants for blackeye bean production in California. Inoculum should be used when planting into a field that has never had blackeye beans before, but for other conditions the value of inoculants is not known. The peat form of inoculum is relatively inexpensive, and some growers make a routine practice of adding this inoculum to seed when fields have not been planted to blackeye beans for several years. Cowpea inoculum is available from warehouses that supply blackeye bean seed.

Irrigation Management

Virtually all blackeye bean plantings in California are irrigated. Most are furrow irrigated with beds spaced from 30 inches to 40 inches apart. A significant acreage is planted flat and either flood irrigated within borders or irrigated with overhead sprinklers.

Pre-irrigation

Land is usually pre-irrigated so that before planting blackeye bean seed can be planted into moisture.

Pre-irrigation can be used to leach salts and bring the soil profile to field capacity without the potentially harmful waterlogging or cooling effects that can occur if irrigations are applied just after seedling emergence. By bringing the eventual root zone to field capacity early in the season, growers encourage deep root growth and enable the crop to more effectively withstand droughts later in the season that could result from delayed irrigations or from irrigation quantities that are less than crop water requirements. The amount of water needed for pre-irrigation depends upon prior rainfall and evaporative losses and the water-holding capacity and depth of the soil. Generally, sufficient water should be applied to bring the eventual root zone, which can be as deep as 5 feet, to field capacity. If water is expensive or in short supply, it may be advisable to pre-irrigate with only enough water to bring the first 3 feet of soil to field capacity.

Scheduling irrigations

Timing of the first irrigation varies from 2 to 7 weeks after planting, with many growers irrigating after 4 weeks. Where water is in short supply and the soil is not too sandy, the first irrigation can be delayed until floral buds first appear (fig. 5), which may be 35 days after planting in hot conditions or up to 50 days in cool conditions. The CB5 variety resists drought during the vegetative stage; it can be water-stressed to the point that the foliage turns bluish and still suffer no yield losses. There are a number of advantages to imposing a vegetative-stage drought: fewer irrigations, fewer early season weeds, warmer soil, about 4 inches less crop water use, and plants that generally develop a deeper root system, enabling them to better withstand drought later in the season. The crop should be carefully monitored if it is being subjected to drought during the vegetative stage. Drought enhances problems caused by the lesser corn stalk borer (*Elasmopalpus lignosellus*) or charcoal rot (*Macrophomina phaseolina*). If you detect these problems, irrigate the crop as soon as possible, since irrigation is an effective means for reducing them. It may also be advisable to apply the first irrigation early if the plants appear to be stunted as a result of factors other than cool weather or when growing the compact variety CB46 on wide beds. In no case should the first irrigation be delayed until flowering begins, since the stress imposed by such a delay usually reduces bean yields. Sufficient water should be applied at the first irrigation to bring the top 5 feet of soil to field capacity. Depletion of soil water during the first 35 to 50 days after planting would be about 3 to 4 inches.

Intervals between the first, second, and other subsequent irrigations can be estimated by the water budget method. Irrigation experiments with CB5 have demonstrated that the total permissible depletion of soil water during flowering and pod filling stages, without causing yield loss, varied between 50 and 75 percent of the available water in the top 3 feet of soil. The optimal percentage depletion varies depending upon local conditions. For example, with a loamy soil that supports strong root development, 75 percent depletion of available soil water could be permitted in the top 3 feet; in contrast, where high bulk soil density or other factors result in sparse rooting or in a sandy soil, it may be safer to permit only 50 percent depletion in the top 3 feet. The available water in recently irrigated soil can range from 1 inch of water per foot of soil in sandy loam soils to 2 inches per foot in clay loam soils. The total permissible depletion, therefore, ranges from 1.5 inches (with 50 percent depletion in a sandy loam soil) to 4.5 inches (with 75 percent depletion in a clay loam soil).

If replenishment of root zone water is limited by slow infiltration as a result of soil surface sealing, it may be necessary to irrigate more frequently than is indicated by the water budget method. Tensiometers placed between plants in the row with their tips 12 to 36 inches deep can be used to test whether irrigations are replenishing the root zone. About 1 day after an irrigation, a tensiometer will read 0 to 10 centibars if the root zone has been recharged around its tip. Where possible, the slow infiltration problem should be solved by applying gypsum or by deep-ripping before planting or cultivation. In some soils, surface sealing becomes more pronounced as the season progresses. In this case, irrigations should be more frequent and should apply less water per irrigation toward the end of the season. Tensiometers may be used to determine when blackeye beans should be irrigated during flowering and pod development. Studies on a fine sandy loam soil indicated that maximum yields can be achieved if soil moisture tensions are maintained below 48 centibars for tensiometers with their tips 12 inches into the soil. If the tips are deeper than 12 inches, the critical value for initiating irrigations would be less than 48 centibars. Tensiometers 36 inches deep are useful for determining whether sufficient water has penetrated the soil to more fully recharge the profile.

Once blackeye beans have achieved at least 90 percent ground cover, their water use will approach reference crop evapotranspiration rates. Growers can obtain actual or average values for reference crop evapotranspiration from local water districts or farm advisors. The average reference crop evapotranspiration during July and August in blackeye bean production areas is between 1.5 and 2 inches per week.

The average irrigation interval can be estimated by dividing the total permissible depletion by the average water use. These intervals can range from once every 3 weeks if the crop water use is low (1.5 inches per week) and the permissible depletion from the soil is high (4.5 inches) to once every 5 days on a sandy loam soil (permissible depletion 1.5 inches) when the crop water use is high (2 inches per week). Growers can estimate the actual date when a blackeye bean crop needs irrigation by totaling the actual reference crop evapotranspiration per day for each day since the last irrigation and subtracting any rain that has occurred. When this total approaches the total permissible depletion value for the particular soil, the crop should be irrigated.

The water budget approach provides only an approximate indication of irrigation need and may be improved by fine tuning. Visual observations are useful. For a blackeye bean crop at the flowering and pod-filling stages, if the canopy develops a blue appearance in the afternoon it probably is not being irrigated often enough, and may produce lower yields than a more-frequently irrigated crop. Where a small part of a field exhibits drought symptoms sooner than the rest, the blue appearance of the canopy may be a good indication that it's time to irrigate the entire field. A blackeye bean crop that is irrigated too frequently will have rank vegetative growth. It may have the same potential to produce beans as an optimally irrigated crop, but it could be more difficult to manage. Blackeye beans with rank vegetative growth are more attractive to lygus bugs, may lodge, and can be more difficult to cut, dry-down, and thresh.

Some people believe that it is necessary to withhold irrigation in order to promote pod set by checking vegetative growth, but there are no research data to support this for blackeye beans. This belief may have arisen from confusion over what is cause and what is effect. A crop whose first flush of flowers has been damaged by lygus or hot weather will tend to exhibit rank vegetative growth, but it is the poor pod set that is responsible for the rank vegetative growth. Another possible explanation is that blackeye beans with rank vegetative growth may appear to have a low pod set just because it's hard to see pods from the edge of the field. Irrespective of the cause, rank vegetative growth should be avoided, especially if it results in lodging. The key to effective irrigation management during flowering and pod filling is consistency. During each irrigation cycle, water should be withheld until the crop reaches the same optimal depletion of available soil moisture or symptoms of mild stress.

The decision of when to terminate irrigations is difficult, and requires inspection of individual fields and an understanding of how long the water in a particular soil can carry the crop. First, it is useful to determine whether sufficient pods have been set from the first flush of flowers. With rows 30 inches apart, there should be at least three pods per inch of row, and for 40-inch rows there should be at least four pods per inch of row. The more mature pods should be well-filled, averaging eight seeds per pod. These levels of podding would produce approximately 24 cwt per acre. If pod set is less than this, the grower should consider continuing irrigations to try to obtain a second substantial pod set. For this to occur, more than 50 percent of the plants would need to have healthy roots and some green leaves. A second pod set requires enough irrigation to carry the crop for 5 to 7 more weeks.

When the grower has decided to promote crop drying and maturation, he or she must determine whether there is sufficient water in the soil to permit most of the beans to achieve maximum size. Small pods less than 1 inch long will take 2 or 3 weeks to reach maturity under hot or cooler conditions, respectively. The final irrigation will provide enough moisture to carry the crop to maturity for 1½ to 2 times the optimal irrigation interval used during flowering and pod filling. For example, if the optimal irrigation interval were 10 days, then a terminal irrigation could provide sufficient water for 15 to 20 days. This period could enable most of the young pods on the plant to mature, but any pods set after the final irrigation would not reach full size. Too-early a termination of irrigation results in smaller beans. Once the decision has been made to terminate irrigation and the crop has been left without water for longer than the optimal interval, it may not be possible to reverse the decision. The combination of drought and a substantial pod load will cause plants to initiate an irreversible senescence.

Amounts of water to be applied

The amounts of water provided in irrigations should be sufficient to replenish the root zone to field capacity unless slow infiltration rates indicate that less water should be applied. You can estimate the minimum amount needed by totaling the daily reference crop evapotranspiration since the last irrigation and subtracting any rainfall. With optimal irrigation intervals that do not exceed permissible depletion of available soil water, this amount can vary between 1.5 inches in a sandy loam soil to 4.5 inches in a clay loam soil. Since most irrigation systems do not apply water uniformly, growers should apply more than the minimal water requirements to insure that drier parts of the field receive adequate water.

The minimum seasonal irrigation needed to produce a blackeye bean crop being managed for full yield from one pod set is 16 to 18 inches. This estimate assumes a pre-irrigation of 4 inches, and irrigations of 4 inches when floral buds first appear and 8 to 10 inches during 5 to 6 weeks of flowering and pod-filling. If additional irrigations are needed during the vegetative stage, they could increase the total irrigation requirement to 20 or more inches. Irrigating for a second flush of pods could require an additional 8 to 12 inches of water. Irrigation requirements are further increased by any water required to leach salts or to compensate for an inefficient irrigation system.

Many surface irrigation systems cannot uniformly apply small quantities of water. A system that will uniformly apply 4 inches or less can be managed to minimize the water requirements of blackeye beans in most soil conditions. If the irrigation system has a minimal application in excess of 4 inches or if the soil is sandy and has a permissible depletion below the minimal amount that can be applied by the irrigation system, water will be wasted as drainage, and soil nutrients will be lost to leaching. Any of the present irrigation systems used with blackeye beans—furrow, flood irrigated within borders, or sprinkler irrigated—can produce high yields if they suit the particular local conditions and are well designed and effectively managed.

Weed Control

Effective weed control is critical for blackeye bean production. Weeds consume about as much water as blackeye beans on a plant dry matter basis. Weeds also are excellent competitors for soil nutrients. This is probably one of the ways that nutsedge competes with blackeye beans, in that it competes heavily for nutrients during early growth stages. Taller weeds are major competitors for light. Weeds such as pigweed, foxtail, black and hairy nightshades, and groundcherry have the ability to screen out much of the light and substantially reduce blackeye bean yields. A field is capable of producing only a certain amount of dry matter in a given time, provided other crop production factors are optimal. If weeds make up a significant portion of the plant population, crop yield will be correspondingly reduced.

Weeds can result in additional production problems. Black nightshade (fig. 8) can cause serious reductions in bean quality, since beans can be stained at harvest by a purple pigment from its crushed berries. A small number of nightshade plants—certainly fewer than would cause significant reductions in yield—can cause substantial bean staining, and it may be necessary to remove the weeds from windrows by hand. Harvesting is also made difficult by any large weeds that remain green at threshing. These weeds slow the drying of beans and "ball-up" in the thresher.

Figure 8. Black nightshade, *Solanum nigrum*.

Weed control in blackeye beans includes both cultural and chemical control strategies. Cultural control techniques have been quite successful. If possible, fields that are free of problem weeds like black nightshade and nutsedge should be selected for planting. These weeds can build up after blackeye beans or some other warm-season crops in the rotation (such as cotton,) are produced on a field for a few years. Rotation to crops such as winter cereals that are less hospitable to these weeds or that allow easier control can reduce nightshade and nutsedge infestations in these fields.

Dry-surface mulch planting, also known as planting to moisture, is one of the most effective cultural weed control strategies. Fortunately, it is often used as a normal production practice in blackeye beans. Mulch planting involves planting seed through the dry surface soil into a moist soil layer beneath. The relatively large crop seed has enough moisture and strength to germinate and emerge through the dry mulch, but weed seed, which commonly germinates in the top inch of soil, cannot do so in dry mulch. Irrigation is then delayed until the crop is well established and can outcompete the small weeds that emerge after the first irrigation. Mulch planting uses either stored soil moisture from late winter or spring rains or moisture from pre-irrigation. Pre-irrigation followed by a shallow cultivation is an excellent way to germinate and destroy weeds that are potentially serious problems in blackeye beans. Pre-irrigation should come as close before planting as possible in order to bring up weeds whose soil temperature requirements are similar to those of blackeye beans. Pre-irrigation in the winter, for example, would germinate winter weeds that pose no threat during the normal blackeye bean growing season.

Cultivation can be a very effective weed-management procedure. Small broadleaf weeds and grasses can be uprooted or smothered in a covering of dry soil. Cultivation is always more successful when weeds are small. Mulch planting allows the crop to reach a size suitable for cultivation while weeds are still in the seedling stage. Care should be taken to avoid irrigation for several hours after cultivation so that cultivated weeds will dry out. If irrigation immediately follows cultivation, some weeds will survive in their new location.

Herbicides registered for use on blackeye beans and effective methods for using them are described in "Dry Bean Pest Management Guidelines" (available from DANR Communication Services as part of Publication 3339, *UC IPM Pest Management Guidelines*, or as an individual crop guideline).

Nematode Control

Nematodes are microscopic, wormlike organisms that inhabit soil and roots. Of the many types of nematode in fields, only a few are plant parasites, and of these only the root-knot nematodes are of concern to the blackeye bean grower. Several common species of root-knot nematodes in California attack and injure blackeye beans. They belong to the genus *Meloidogyne*, and include the species *Meloidogyne incognita*, *M. javanica*, *M. arenaria*, and *M. hapla*. The first two species are the most widespread and most likely to be responsible for damage to blackeye beans in the San Joaquin Valley. These nematodes have a wide host range and are able to attack and reproduce on many crops and on some common weeds.

Biology

The root-knot nematode has a simple life cycle, part in soil and part in roots. The infective juvenile or larva hatches from the egg and moves through soil. After finding a suitable root, it penetrates and enters the area just behind the root tip. The juvenile nematode starts to feed on root cells, which enlarge to form a nurse cell system that provides a nutrient source. The nematode develops through additional juvenile stages and becomes an adult male or female. Males leave the root and do not feed much. The female swells up into a pear-shaped form within the root and may produce several hundred eggs, which are laid in a jellylike mass. This egg mass may be visible on the root surface. Once the eggs hatch, the juveniles start another generation of infection. Several generations can occur in a single growing season, each cycle taking about 3 weeks to 1 month in warm, moist soil. Eggs produced late in the season can remain unhatched through winter until the spring. Some juveniles that hatch late in the growing season may survive in the soil to infect a new crop the following spring. Populations of eggs and juveniles decrease during winter by as much as 80 to 90 percent, but the residual population is often sufficient to cause crop injury the following year.

Plant symptoms

The only distinctive symptom of root-knot nematode infection is the presence of root galls caused by the proliferation of root tissue surrounding the developing nematode (fig. 9). A gall may contain one or more female nematodes, which are visible under a hand lens as tiny white pearls when galled roots are cut open. The galls or "knots" on roots can appear quite small and beadlike in early to midseason, when infection is getting started. Small galls may be found on small lateral roots throughout the life of the crop. Galls on primary roots may become large (up to ¼ or 1 inch in diameter) and coalesce into continuous lengths of unevenly swollen root. As the season progresses, galled roots are susceptible to infection with secondary root-rotting organisms attracted to galled tissues. This secondary infection leads to rot and a general breakdown of galled roots, increasing the damage caused by root-knot nematodes.

Infected root systems are less extensive than healthy root systems and have a lower capacity for uptake of water and nutrients. The combination of a reduced supply of soil nutrients and the removal of plant nutrients and carbohydrates by nematode feeding cause plants to become stunted, and reduce blackeye bean yields. Heavily infected plants may show symptoms of water and nutrient stress, including wilting, mild yellowing of leaves, and senescence, even in well-irrigated and well-fertilized soils. Stress symptoms are more likely to show toward the end of an irrigation cycle. Less-heavily infected plantings may appear quite normal aboveground, even though they may sustain significant yield reductions.

Root-knot nematodes are commonly associated with soils containing 50 percent or more sand: sands, loamy sands, and sandy loams. Field infestations usually are unevenly distributed, often with irregular, patchy occurrences of damaged plants that coincide with sandy areas within the field. Previous crop patterns can also influence nematode distribution, such as when a host crop causing nematode buildup was grown only on one portion of the current blackeye bean field, or when a portion of the field was recently fallowed or planted to a nonhost crop, causing a decline in nematode population. The point of origin of the nematode infestation—for example, where cultivation equipment with nematode-contaminated soil was brought into the field—can also determine nematode distribution within the field.

Sampling, detection, and diagnosis

Two main approaches to detection and sampling for nematodes are checking for root gall symptoms and collecting and analyzing soil samples.

Root gall symptoms. The visible presence of nematode-induced galls on roots can be used as a definitive diagnostic characteristic for the presence of root-knot nematode. With blackeye beans as with other leguminous plants, it is important to distinguish between root-knot nematode galls (fig. 9) and nitrogen-fixing root nodules induced by *Rhizobium* spp. (fig. 7). The primary difference between the two is that the nematode gall is a swollen part of the actual root tissue and cannot be pulled off or rubbed off without breaking the root itself. The *Rhizobium* nodule is not an integral part of the root, but rather is attached to the outside of the root and it can be removed easily by rubbing with a finger. In addition, nodules tend to be more spherical than galls, and they usually are pink inside. Galls are the same color as roots inside and out.

Root galls are visible starting about a month after planting and are most obvious from midseason onward. You can check for galls on roots to confirm the presence of root-knot nematodes, and by sampling roots from both stunted and healthy plants within the field you can confirm that their presence and severity are the cause of stunting or other symptoms. When sampling, dig roots of several plants with a shovel, being careful to ease the roots out of the soil in order to obtain both large and small roots.

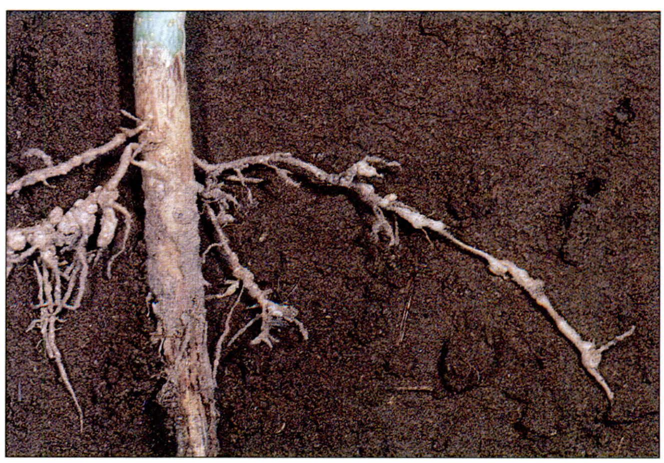

Figure 9. Galls on roots of blackeye bean cultivar CB46, induced by an aggressive population of the root-knot nematode, *Meloidogyne incognita.*

Tap the roots on the shovel to remove adhering soil and expose galls, or gently wash the soil off the roots. Sketch a simple field map to record the areas sampled and the absence and presence or extent of root galling.

Field observations have revealed that blackeye bean variety CB3 does not show clear root gall symptoms, even though it is susceptible to root-knot nematodes and supports considerable nematode reproduction. Resistant plants do not form galls or support much nematode reproduction in response to certain nematodes. For example, CB46, CB88, and CB5 do not gall when challenged with nonaggressive populations of *M. incognita*. However, *M. javanica* and the aggressive forms of *M. incognita* induce gall and egg production on roots of these same varieties. Many common weeds including nightshade, groundcherry, pigweed, and lambsquarter are hosts for root-knot nematode and can be checked for presence of root galls as indicators of nematode infestation. Also, other crops in rotation with blackeye bean should be checked for root galls to help in year-to-year nematode management planning.

Soil sampling. Samples can be taken at any time, but nematode population levels vary with time of year relative to the crop. Populations are highest in the fall and then drop during winter. Samples taken in the fall provide an indication of their potential to injure a blackeye bean crop, but the natural decrease in population during winter should be taken into consideration.

Field sampling involves taking soil cores from several sub-areas of the field chosen according to previous plant growth, soil type, or crop history differences. If this is not possible, take samples from blocks of about 5 to 10 acres throughout the field. Fifteen to twenty cores should be taken to represent each block uniformly and effectively. The samples from each block should be consolidated into a plastic bag, kept cool, and given to a diagnostic laboratory for analysis. Some laboratories will do the sampling as well as the analysis. Sample results will be in numbers of juveniles per weight (usually per kilogram) or volume of soil.

Although some quantitative information is available to relate preplant root-knot nematode population levels in samples to potential yield loss, it is based only on nonaggressive *M. incognita* impact on the CB5 variety. There are several other potential combinations of blackeye bean varieties and nematode biotypes that can lead to much more serious crop damage, but no reliable data are available to predict the results of most of these combinations.

The data in table 2 summarize the susceptibility of four blackeye bean varieties to three types of root-knot nematode and to Fusarium wilt. Most laboratories cannot provide a species identification for root-knot nematodes and cannot provide information on their aggressiveness. Previous crop history and field observation can provide indications of the species that might be present: for example, *M. incognita*, unlike *M. javanica*, reproduces on Acala cotton, whereas the reverse is true for alfalfa. Knowledge of whether the root-knot infestation is *M. incognita*, *M. javanica*, or a mixture has some limited utility. If *M. javanica* is present, direct nematode injury is likely regardless of variety. If *M. incognita* is present, injury to *M. incognita*-resistant varieties CB5, CB46, and CB88 will depend on the aggressiveness of the population. The aggressiveness of an *M. incognita* population can be determined only by direct observation of its effect on these resistant varieties. This underscores the importance of good field observation and record keeping on the presence and impact of root-knot nematodes.

Management options and guidelines

In planning a nematode management program, it is important to consider how combinations of two or more strategies can be used in an integrated approach to reduce nematode populations and crop loss. For example, rotation strategies can be combined with the use of nematode-resistant blackeye bean varieties or fallow breaks. A combination of strategies should increase nematode control, and it may well help varietal resistance by reducing the potential for selection of aggressive, resistance-breaking nematode populations.

Nematicides. The loss of registration of most low- to moderate-priced soil fumigant nematicides has all but eliminated the chemical control of nematodes on blackeye beans. Formulations of metam-sodium (e.g., Vapam, Soil Prep) are being used in some crops, but the high cost and difficulty of effective application preclude their routine use for blackeye beans. Nonfumigants such as aldicarb (Temik) are not effective against significant root-knot infestations at the low rates used for insect control. At present, direct use of nematicides for blackeye beans is therefore not very practical. Blackeye beans may benefit indirectly if a nematicide treatment for a previous crop with a higher cash value has a residual effect in limiting the buildup of nematode populations. "Dry Bean Pest Management Guidelines" and other DANR Communication Services publications provide information about which nematicides are registered for use on which specific crops and about effective methods for their use.

Resistance. California blackeye bean variety CB3 is susceptible to all root-knot nematode populations, and damage can be expected. However, root galling is limited on this variety, so it is somewhat tolerant to infection. The other cultivars (CB5, CB46 and CB88) all share the same type of resistance, the single dominant gene *Rk*, which is effective against nonaggressive populations of *M. incognita* but not against the aggressive *M. incognita* populations, nor against *M. javanica* populations in California. The resistance to *M. incognita* is very useful, since most populations appear to be nonaggressive. In infested fields where resistance is effective, yields are normal or near normal and the nematode reproduction rate is lower, which also benefits following crops. However, aggressive *M. incognita* populations have been found at Poplar (Tulare County) and Denair (Stanislaus County), and may be present elsewhere. *Meloidogyne javanica* is widely distributed. Attempts are underway to develop blackeye bean varieties that are resistant to a broad range of root-knot nematodes.

Rotation and fallow. Crop rotations for nematode management alternate blackeye beans with nonhost crops or resistant varieties of other crops, thereby decreasing nematode population levels. Consequently, when the blackeye bean crop is grown, the reduced nematode population should cause less damage and be more easily controlled. The wide host ranges of root-knot nematodes and the scarcity of crops having resistant varieties limit the number of nonhost or resistant plantings available for rotation with blackeye beans. Here are some crops suitable for rotation with blackeye beans, along with their specific advantages:

- Resistant tomato varieties greatly reduce *M. incognita* and *M. javanica* populations.
- Acala cotton reduces *M. javanica* and some *M. incognita* populations.
- Weed-free alfalfa reduces *M. incognita*.
- Large limas (White Ventura N and Maria) reduce *M. incognita*.

Table 2. Summary of root-knot nematode and Fusarium wilt resistance and susceptibility of blackeye bean varieties and the likelihood of crop damage from infection

	Cultivar		
Nematode	CB3	CB5	CB46 & CB88
M. incognita (nonaggressive)	susceptible*	resistant	resistant
M. incognita (aggressive)	susceptible	susceptible	susceptible
M. javanica	susceptible	susceptible	susceptible
Fusarium wilt (race 3)	resistant (unless *M. javanica* is present)	susceptible (damage is worse if aggressive *M. incognita* or *M. javanica* is present)	resistant (unless *M. javanica* is present)

* "Susceptible" varieties are likely to exhibit crop damage, whereas "resistant" varieties are not.

- Winter crops (e.g., onions and garlic) generally are not hosts of root-knot nematodes.
- Summer weed-free fallow, especially following a winter crop, will decrease root-knot nematode populations.
- Fumigated or resistant sweetpotato (e.g., Jewel) plantings reduce nematode reproduction.
- Fields coming out of *Prunus* tree fruit production (almond, nectarine, peach, plum) grown on the root-knot resistant rootstock Nemaguard should not have damaging root-knot nematode population levels.

Other strategies. Some resistant or nonhost cover crops look quite promising for reducing root-knot. Cahaba white vetch and certain grasses are examples. Green manuring by growing and then disking-in green crops of mustard, rapeseed, or vetch has shown some promise in reducing nematode populations. Solarization of moist soil under a plastic tarp also can decrease root-knot populations. These are strategies that have potential but they have not been developed fully and may or may not be compatible with a particular blackeye bean production system.

Root-knot nematode–Fusarium wilt interaction

Root-knot nematodes can influence the expression and severity of Fusarium wilt disease of blackeye beans. The following summary statements have practical relevance to blackeye bean production.

The root-knot nematodes *M. incognita* and *M. javanica* cause an increase in the severity of Fusarium wilt disease on the Fusarium-susceptible blackeye bean variety CB5, resulting in greater yield loss from wilt than occurs in the absence of nematodes. The other varieties available are genetically resistant to the common race of Fusarium wilt in California.

For Fusarium wilt-resistant varieties, including CB46, CB88, and CB3, the following are true:

- The resistance is very effective in controlling wilt disease in the absence of nematodes.
- In the presence of *M. incognita,* including both the aggressive and nonaggressive forms of this nematode, wilt resistance remains effective. In other words, the nematode is unable to break the protection of the wilt resistance, although the nematode may cause direct injury to the blackeye bean plant.
- In the presence of *M. javanica,* wilt resistance may be reduced by nematode infection such that the severity of wilt symptoms and injury to plants increase to a significant extent.
- The influence of nematodes on the newly discovered Fusarium wilt race 4 is not known, but nematodes are likely to increase wilt damage on wilt-susceptible varieties. All currently available varieties are susceptible to wilt race 4; however, the known distribution of race 4 in California is very limited as of this writing.
- General recommendations for control of wilt disease on blackeye beans are centered on the use of the wilt-resistant bean varieties CB46 and CB88 and avoidance of the wilt-susceptible bean variety CB5. In fields containing both wilt and the nematode *M. javanica*, efforts to reduce nematode populations should be considered. Where *M. incognita* is present, wilt resistance should remain effective, although direct plant damage from root-knot may occur if the nematodes are of the aggressive type.

Disease Problems

Seedling diseases

Seedling diseases of blackeye beans usually are most damaging when soil temperatures are cooler than optimal and plant emergence is delayed, and these conditions may be aggravated by deep planting. Unduly wet soil, caused by rain or excessive irrigation, also favors seedling diseases. Main pathogens that cause seedling diseases are *Pythium ultimum,* possibly one or two other species of *Pythium,* and *Rhizoctonia solani.*

Pythium usually kills seedlings before they can emerge. *Rhizoctonia* can cause preemergence death of seedlings, but more often it attacks the plants after emergence. A sunken oval canker at the base of the stem is the most characteristic symptom. If the canker girdles the stem, the plant usually dies, though in some cases the plant will recover. *Rhizoctonia* cankers can sometimes be seen on older plants.

The most effective cultural practice for controlling seedling diseases of blackeye beans is to plant when soil temperatures favor rapid emergence. However, since cool weather and unseasonable rain can't always be predicted, seed treatment with suitable fungicides provides a reasonable measure of protection from loss of seedlings to these fungi. *Pythium* and *Rhizoctonia* differ in their sensitivity to fungicides, so seeds should be treated with fungicides that are active against both types of pathogen. For instance, the chemical metalaxyl can provide excellent control of *Pythium* but has no activity against *Rhizoctonia;* conversely, pentachloronitrobenzene (PCNB) is active against *Rhizoctonia* but not against *Pythium.* State and federal regulations govern the use of fungicides, and label requirements must be followed. "Dry Bean Pest Management Guidelines" provides information on fungicides that are registered for use with blackeye beans.

Fusarium wilt

Fusarium wilt, caused by *Fusarium oxysporum* f. sp. *tracheiphilum,* is probably the only major disease of blackeye beans in California at this time. The disease has become relatively widespread: it was diagnosed in 74 percent of 47 fields in Tulare and Kern counties in 1989. Disease symptoms are easily recognized in the field as yellowing and dying lower leaves and vascular discoloration of roots and stems. If the root and stem of the plant are cut slantwise with a sharp knife, the woody tissue will be tan to brown in color, and the discoloration will extend from the tap root upward through the stem (fig. 10). This symptom, called vascular necrosis, occurs because the fungus is systemic throughout the plant. Roots of blackeye beans are not rotted, but the shoots exhibit early cut-out and low yields. Resistant blackeye bean varieties may exhibit some vascular browning of the roots, but the discoloration does not extend up into the stem, and they maintain high yields in wilt-infested fields. Other crops grown in rotation with blackeye beans are not known to be susceptible to this specific disease.

The Fusarium wilt fungus produces globose spores called chlamydospores in diseased tissue, and these spores can survive in soil for many years, even in the absence of blackeye beans or other cowpeas. In spring, the spores germinate and penetrate roots, colonizing water-conducting tissues of the plant, and impairing water uptake and movement in the plant. Spores of the fungus from infected stems can be deposited on seeds during the threshing process, but there is no evidence that the fungus can be transmitted inside the seed. *Fusarium* spores on the seed and in the soil provide a means of dissemination to land that was previously free of Fusarium wilt.

At least four pathologic races of the fungus exist. A pathologic race is a strain that is indistinguishable by spore morphology from other races but is more pathogenic to several varieties of cowpea. Currently, race 3 is widely distributed in California. A new race (race 4) has recently been discovered, but there are no indications of wide distribution.

The only effective way to control Fusarium wilt is to use resistant varieties (tables 1 and 2). Because spores persist in soil and plant debris for many years, rotation to other crops does not provide effective control.

Root rots

Several root diseases affect cowpea plants, and in some cases they have been directly implicated in a field problem known as early cut-out. In such a case, plants die after producing the first flush of pods. Several root-rotting fungi are associated with this phenomenon in addition to Fusarium wilt. *Fusarium solani* f. sp. *phaseoli* and *Thielaviopsis basicola* have been isolated from affected roots. Longitudinal cracks in the bark and reddish to brown discolored lesions are characteristic of the disease or diseases. Both fungi can produce root symptoms under controlled conditions that are similar to root rot symptoms observed in the field. It is possible that both fungi are involved. There is no known control of these diseases. Both *Fusarium solani* and *Thielaviopsis basicola* produce spores that persist for many years in soil, so crop rotation would not likely be helpful.

Ashy stem blight or "charcoal rot," caused by *Macrophomina phaseolina*, is most frequently seen too late in the season to cause reductions in yield. The disease is characterized by a faded tan stem color and a scattering of small black specks that are embedded in the diseased stem surface and woody tissue. These "ashy" particles are sclerotia, dark masses of tightly knotted fungal material that can live for years in soil. Ashy stem blight is a potentially serious disease, but its occurrence early in the season has been limited to fields that have been subject to long periods of drought stress or high temperatures. The only known control method is irrigation to minimize drought stress.

Pythium wilt is characterized by a collapse of the stem just above the soil line. *Pythium aphanidermatum*, a water mold, is often found in diseased tissue and

Figure 10. Vascular discoloration of blackeye bean roots and stems, caused by Fusarium wilt.

infection is favored by high temperatures and waterlogging. The fungus infects the root and makes its way up the pith in the stem, from which it infects the woody and soft tissues. *Phytophthora drechsleri* has been isolated from rotted roots in two fields and has been proven to be a cause of root rot on cowpeas. This root disease is favored by continued periods of waterlogged soil. The only known control method for these diseases is to use management practices that minimize the extent and duration of waterlogging in soil.

Bacterial diseases

Bacterial blight, caused by *Xanthomonas campestris* pv. *vignicola*, has been found only on rare occasions in California in southern pea varieties of cowpea grown for seed. Southern peas grown in rainy conditions in other states contract the disease and it becomes seedborne. When infected seeds are grown in California, the disease can spread, especially if the crop is grown under overhead irrigation. California blackeye bean varieties are susceptible to this disease and, even though no infected blackeye beans have yet been detected in California, we include the symptoms here because it is a damaging disease. The initial symptoms of bacterial blight infection show up as tiny water-soaked dots on leaves. These dots remain small as the surrounding tissue dies and turns tan or orange with a yellow halo, and lower leaves senesce. Brown cracking may occur on the stem and peduncles. In California, growers can avoid the disease by using disease-free seed and surface irrigation systems to produce seed of either southern peas or blackeye bean varieties.

Viral diseases

Curly top virus disease can infect blackeye beans. This disease is transmitted by the beet leafhopper. Plants infected early by curly top virus are stunted, do not recover, and produce very little yield. On rare occasions fields of blackeye beans have been severely damaged by this virus.

Mosaic-inducing viruses that infect blackeye beans are present in California. They usually cause only minor problems, but are more prevalent with late-planted blackeye beans and can be seedborne and so have implications for seed production. Cucumber mosaic (CMV) is the most widespread virus, but southern bean mosaic (SBMV), blackeye bean cowpea mosaic (BlCMV), and alfalfa mosaic also have been detected in blackeye beans in California. CMV, SBMV, and BlCMV are seed-transmissible in blackeye beans. In general, CMV causes relatively little yield loss in blackeye beans or southern peas, but in mixed infections with BlCMV plants can be severely stunted, and BlCMV by itself can substantially reduce yield. Cowpea aphids can transmit both CMV and BlCMV. The best way to determine whether a specific virus disease is present in blackeye beans or other cowpeas is to have serological assays made in well-equipped laboratories that have appropriate antisera.

A principal control method for CMV, SBMV, and BlCMV at present involves the use of disease-free seed and avoidance of late planting in parts of the southern San Joaquin Valley where viral diseases are most prevalent. Blackeye bean fields that have mosaic virus-infected plants should not be used for seed.

Insect and Mite Pest Management

The Integrated Pest Management (IPM) approach recognizes that there are different types of insects present in fields at any time during the season. Some of these insects can cause substantial yield reductions, some are of limited concern, and some play beneficial roles in regulating other insects. Key pests should receive the greatest attention. Depending on the stage of development of the blackeye bean plant, the roles of these insects change. Critical to an IPM approach is an understanding of the vulnerable stages of crop development and of which insects most affect these stages.

For blackeye beans, the period from initiation of flower buds to pod filling is extremely important. Feeding by lygus bugs or stink bugs can substantially damage flower buds (plate 3) and pods, resulting in lower yields or a protracted season. If carbohydrate supplies are reduced while pods are filling (whether because aphids are sucking sap or because mites or armyworms have eaten away the plants' leaf surface), blackeye bean yields will be reduced.

Surrounding crops can have both positive and negative effects on pest populations in blackeye beans. An understanding of these effects is important for effective pest management.

Lygus bugs

Lygus hesperus, L. elisus

Description and biology. Lygus bugs are commonly occurring plant-sucking insects found in many crops in

California. Their hosts include alfalfa, cotton, sugarbeet, safflower, various beans, and numerous weeds that occur on roadsides, orchards, and vines, and in rangelands. The insect feeds by inserting its mouth parts into tender tissue, such as growing points, floral buds, or young developing seeds. This results in yield losses and blemished beans. Lygus is the major insect pest problem of blackeye beans.

A survey of warehouses concerning the 1993 blackeye bean crop gave the following results. The area of the Central Valley south of Fresno and Kerman, which handled 58 percent of the crop, reported 97 percent lygus damage, with 61 percent of the beans graded less than U.S. No. 1 because of this damage. The central area between Stockton and Fresno, which handled 23 percent of the crop, reported 22 percent lygus damage, and 11 percent graded less than No. 1. Substantial additional losses in yield probably resulted from lygus damage to floral buds.

Lygus bug adults are about ¼ inch long and vary in color from green to reddish brown (fig. 11). The adult has a triangular pattern resembling a cape in the center of its back. Immature insects (nymphs) are smaller, and usually green with red antennae. Later instars have black dots on their backs. Eggs are difficult to see because they are laid into plant tissue such as leaf blades or soft stems.

Lygus bugs migrate to bean fields from other crops or weeds. Lygus as presexual adults overwinter on plants in uncultivated areas and rangelands surrounding the Central Valley, in overwintered sugarbeets, in weedy orchards, or on plants along rivers or sloughs. During late winter, they reproduce on these host plants. If conditions are favorable, one or more generations of lygus bugs may occur on these hosts, but eventually the insects are forced to migrate as the plants dry out. Depending on these events and the date of blackeye bean planting, movement into beans can occur when the crop is more or less vulnerable. There is no certain way to determine whether the population is migratory or has established residence in the field until the pests begin to reproduce. Care must be taken to be sure that the population has not moved on before applying insecticides.

Damage. Lygus bugs damage floral buds by feeding on them. This damage, often called bud blasting (fig. 6), is very critical during the first flush of buds. While the plant does have some compensatory pow-

Figure 11. The lygus bug, *Lygus hesperus.*

ers to replace these lost fruiting sites, too much loss will set the crop back and reduce yield. Lygus also feed on developing pods and disfigure beans by pitting them as well as reducing the number of beans per pod.

Management. Lygus bugs can be managed with an IPM approach. This includes effective monitoring and multiple control approaches. Sampling involves taking a series of 10 sweeps across the top of two rows of blackeye bean plants. It is important to sample four to six areas of the field and to include the diversity of soil and plant growth types that are present in the field. The current action threshold is 5 lygus per 10 sweeps (0.5 lygus bug per sweep) during the floral bud through small pod stage, and 1 lygus bug per sweep later in the season. The counts include both adults and nymphs.

Chemical treatments are required when the population exceeds these thresholds. Insecticides registered for use on blackeye beans and effective methods for using them are described in "Dry Bean Pest Management Guidelines." Be aware that insecticides to control lygus bugs are broad spectrum and nonspecific and will reduce the number of general predators. Such applications can lead to secondary outbreaks of mites and worms.

Be aware of neighboring crops. Alfalfa for hay is a preferred host of lygus. Lygus bugs will migrate

Figure 12. The cowpea aphid, *Aphis craccivora.*

from alfalfa during cutting and baling, and will move into blackeye beans. When alfalfa is produced in fields next to blackeye beans, it is useful to leave strips of uncut alfalfa to limit lygus bug migration into the blackeye bean fields. Where possible, the harvest dates of multiple alfalfa fields should be staggered to provide lush habitat for lygus bugs as well as vital biological reserves for beneficial insects.

Aphids

Aphis craccivora, A. fabae

Description and biology. Aphids are soft-bodied insects (fig. 12) that feed directly from the plant's vascular system. These insects have complicated life cycles involving winged and wingless forms and can reproduce sexually or asexually depending on the time of year. At the time of year when blackeye beans are available as hosts, males are not required for reproduction. Generation times can be less than 2 weeks, causing aphid populations to increase rapidly.

Damage. Aphids excrete a sugary waste product, honeydew. When fungi feed on the honeydew, a black, sooty mold develops on plant surfaces. This mold can reduce photosynthesis. In addition, aphids compete with developing beans for carbohydrates. Early in the growing season, excessive populations can stunt and kill the plants. Besides reducing yields, the honeydew from late-season populations can make beans sticky and of lower quality, and make threshing more difficult. Aphids also transmit viral diseases.

Management. No sampling method is available for aphids, and no quantifiable action threshold has been established. The natural mortality of aphids is usually high, due to predation and parasitism. Important predators include lady bird beetle in spring and green lacewing in summer. Applications of broad-spectrum insecticides for lygus bug or worm management can reduce populations of beneficial insects and allow aphid populations to increase. Also, early season use of insecticides to control aphids often leads to buildup of other insect pests.

Armyworms

***Spodoptera* spp.**

Description and biology. Armyworm eggs are laid in masses on leaves and covered with scales to give them a white, cottony appearance. Larvae hatch and feed together near the egg mass, and the leaf may be skeletonized. The beet armyworm larva is olive green with a dark back and a broad pale stripe along each side. There is usually a dark spot on the second true leg. The yellowstriped armyworm is darker and less green, with a broad stripe on both sides. Armyworms can become as long as 1½ inches.

Many plants serve as hosts for armyworms including sugarbeet, alfalfa, cotton, and various vegetables. Important weed hosts include pigweed and goosefoot.

Damage. Armyworms are mostly leaf feeders and can cause problems if allowed to defoliate plants to an extreme level, but may not affect bean yield if the defoliation is only moderate. A more serious problem is armyworm feeding on flower buds and developing pods, which can cause a direct loss of yield. Populations are more damaging during late summer.

Management. There is no established sampling procedure for armyworms, and no specific thresholds have been established. When insecticide applications are required, the larger larvae are more difficult to control and may not be adequately controlled by the Bt-type insecticides. Some materials used for lygus bugs have some action against armyworms.

Indigenous biological control is a major factor in managing this pest and in keeping its numbers below damaging levels. Many general predators will feed on small larvae including spiders, big-eyed bugs, damsel bugs, and lacewings. Several parasites are useful in managing this insect, including the parasitic wasp *Hyposoter,* whose female can destroy up to 100 worms during her lifetime. Blackened worms hanging limply from leaves indicate the presence of a viral disease that is controlling the worms.

Cowpea storage weevils

***Callosobruchus maculatus* and other members of the Bruchidae family**

Description and biology. This relatively small beetle (less than ¼ inch) is dull in color with white, red, or blackish markings. Several species infest blackeye beans, but all belong to the seed beetle family and have short, broad snouts. The adult body is teardrop-shaped, wider at the back than at the front. Eggs are laid on the dried pod and larvae burrow into the seed. Immature larvae grow entirely within the bean seed, and then emerge as adults. The entire life cycle takes about 1 month. Under storage conditions, weevils may breed throughout the year.

Damage. This postharvest pest seriously affects bean quality and can result in lower prices for the crop. Infestations can begin in the field or during storage.

Management. Sanitation is the key to managing cowpea storage weevil. Old beans are the source of infestation in the field. Harvesters and storage areas should be cleaned to eliminate sources of weevils for the next crop. Commercial warehouses usually fumigate beans in storage to prevent weevil damage. Beans to be used for seed are usually treated with different fumigants than beans that will be sold for food.

Spider mites

***Tetranychus* spp.**

Description and biology. Spider mites are small web-spinning pests that are related to spiders and have eight legs. The same three species attack both cotton and blackeye beans: two-spotted, Pacific, and strawberry mites. All three can infest the blackeye bean plant at the same time. Mite colors range from creamish brown to light green. These web-spinning mites can complete a generation in 7 to 10 days in summer and form dense colonies under their webbing.

Damage. Mites feed on leaves and reduce the plant's ability to produce photosynthates. They are found on the undersides of leaves, but a white stippling is visible on the upper surface of a leaf where feeding has occurred underneath. Pods can also become infested with mites.

Management. Biological control is an important element of spider mite management. Mites provide a primary food source for many general predators. By reducing weed populations and roadside dust, growers can give mite predators an advantage. Dust embedded in the webbing seems to reduce the effectiveness of predators. In addition, dusty plants transpire less, so the surface temperature of the dusty leaf is higher and allows a more rapid turnover of generations. Mite problems are less severe in sprinkler-irrigated fields.

Mite problems will be increased by insecticides that reduce predator insect populations. When treating for lygus bugs, you must know what the mite population is in the field. If mites are found easily on older leaves at early bloom, an acaricide might be advisable in addition to the lygus treatment.

There is no systematic sampling technique for mites in blackeye beans. Infestations usually begin on lower parts of the plant and move upward as populations increase. One way to check for mites is to pick older leaves at random and inspect them for stippling, and then to turn the leaves over to look for mites. No action thresholds have been established for mite numbers and yield losses in blackeye beans.

Harvesting

Perhaps the most critical operation in the production of dry blackeye beans is the harvest. Weather conditions become uncertain in late September, with threats of wind and rain increasing as the season advances. Serious losses in yield and quality can result from improperly timed harvest operations. Blackeye beans that are subjected to rain while in windrows, for as short a period as three days, can be completely destroyed by pod rots. In contrast, a standing crop can tolerate some rain, even when mature, provided it has the opportunity to dry out.

Cutting

Cutting can start when most pods have at least turned yellow, and beans in any green pods show a definite "eye." Beans in green pods that are not fully developed and do not show an eye will shrivel in the windrow and be blown out of the thresher.

Cutting and windrowing should be done when pods are tough enough to keep shatter losses to a minimum. These operations are usually performed at night or early in the morning when dew is present, and cease when pods become dry and begin to break open. Self-propelled swathers that cut the beans just above the soil surface and windrow them in a single operation are effective, especially for blackeye beans planted without beds. In the more traditional method, custom-made four-, six-, or eight-row tractor-mounted bean cutters are used with sickle bars, circular saws, or rollers to separate the plants in front of the tractor wheels. Rear- or belly-mounted V-shaped knives about 5 feet long with guide rods are used to cut plants 2 to 3 inches below the soil surface and put two rows of plants into a cutter-row. Two or more cutter-rows are put into a windrow, typically with a pick-up windrower. Plants dry more quickly and uniformly if the windrow is loose.

Threshing

Blackeye beans are easily damaged during threshing, and usually require specially designed harvesters to accommodate the massive vines with a minimum of cracking and splitting of beans. Self-propelled and pull-type harvesters are used.

There have been some attempts to direct-combine blackeye beans, but the usual result is either too many split beans or too many unthreshed pods. With improvements in combine design and changes in varieties and crop management methods, direct-combining of blackeye beans could become a practical option for future growers.

Blackeye beans are handled in bulk from the thresher to the warehouse using bobtail trucks or, more commonly, trucks with grain beds. Thresher-run beans contain dirt, stones, trash, and split, broken, or discolored beans. Beans are cleaned at the warehouse to bring the lot to the highest possible grade that can be economically achieved. The basic machine used to clean beans is a screen-air separator. Properly adjusted and used, this machine will remove all undesirable materials from beans except dirt and stones of certain sizes, discolored beans, and certain mixtures of other types of beans. Bean lots that contain excessive dirt after screen-air separation often are run over a gravity separator to remove dirt and rocks. Though electric-eye sorting machines have proven useful in separating blackeye beans from other materials, they are not widely used.

Marketing

Producers should become familiar with blackeye bean marketing processes, since they can have a major impact on the crop's profitability. In a free market such as applies to blackeye beans, there is always an opportunity to make higher-than-average returns, and this influences blackeye bean marketing.

Blackeye bean marketing depends upon a number of factors. The sale price of blackeye beans is almost entirely the result of supply and demand: "too many" beans results in low prices. Because demand for blackeye beans is rather stable, supply is usually the major factor determining the price. Blackeye beans can be stored, so they do not have to be marketed at harvest. Individual lots are not co-mingled, and they cannot be marketed until the grower is willing to sell. The producer is free to sell the crop at the optimum time. However, because blackeye beans can be stored, the carryover from the prior crop year can be just as important as the current crop size in determining the supply and market price. Blackeye beans are not traded on the commodities market, there is little or no way to deal in futures, and preseason contracts are seldom available. Furthermore, there are no price supports or other support structures for blackeye beans.

Growers have a number of marketing options, several of which are listed here. They can join and benefit from a cooperative marketing organization, and still have the opportunity to direct-market some of their beans. They can take their beans to a cooperative warehouse that does not market beans, and use cooperative strategies to gain more information about or attempt to control the market. They can use a privately owned warehouse, which usually will assume most of the responsibility for selling beans brought to it. In some years, preseason contracts for the crop are available, eliminating the uncertainty of marketing.

Markets for blackeye beans

The main domestic market for blackeye beans is for the packaged beans sold in supermarkets. Packagers purchase beans in at least truckload, and frequently in hopper car quantities and convert them to consumer-sized packages. The other domestic market for blackeye beans is the canning industry, which although relatively small can influence the demand, and therefore the price, for blackeye beans at certain times of the year.

While many countries import blackeye beans from the United States, only 10 to 30 percent of the crop is exported in an average year. Beans might be sold to a dealer involved in exporting or the dealer might buy for resale to a company specializing in export. The export market is more affected by price than are domestic markets.

Industry structure

Blackeye beans are usually processed, stored, and marketed through privately owned warehouses or farmer-owned cooperative warehouses. Producers who are involved in marketing depend on warehouse managers for help. Warehouse managers are the people bean dealers normally call about the availability of beans. Most warehouse managers act as commission agents, both by linking the producer and dealer through various communications and by furnishing the dealer with bean samples from the warehouse.

Warehouse managers also help producers gather and interpret market information, such as the "feel" for transaction liquidity, the availability of preharvest contracts, and statistical information on crop size, movement, and the like. Market demand, prices, and crop movement are hard to predict and should be monitored closely by producers. This information can be obtained from several sources besides warehouse managers, including field buyers, marketing cooperatives, and the *Bean Marketer,* and *State Bean Market News,* which can be obtained by subscription. Because the almost daily communication between producers, warehouse managers, dealers, packagers, canners, and exporters make the market, and warehouse managers and dealers are in the middle, it is up to them to keep communications flowing. The dealer must remain constantly aware of what the packager or canner is willing to pay, as well as what the producer is willing to sell for, because the various parties seldom agree concerning the value of blackeye beans.

Producers should remember that periods of inactivity are commonplace in the blackeye bean market. The producers' willingness to sell their crop is not all that is necessary to effect a transaction: there must be someone who is willing to buy it, and that usually means the dealer must have a customer with a need for it. While consumption of blackeye beans is year-round, certain periods of consumption and marketing are more active than others.

Generally, about half of the crop moves during the last four months of the calendar year, which are in general the first four months of the marketing year. This movement is largely in preparation for the New Year's rush, a purchasing pattern based on the tradition that eating blackeye beans on New Year's Day brings a person good luck for the rest of the year. During that four-month period, there is usually an opportunity to sell blackeye beans if producers are willing to move them at market price. At other times of the year the price may be higher, but it is not always as easy to find a buyer. Summer months are slow because some consumers, especially those in the primary market of the southeastern United States, have access to fresh blackeye beans. Demand begins to build again in September as packagers use up old stock.

Bean quality considerations

Marketing blackeye beans is more challenging than selling any other California dry bean variety, largely because of variations in quality. What looks like a U.S. No. 1 grade can easily be U.S. Substandard, and vice-versa. Grades for beans are defined in *The United States Standards for Beans,* available from the Federal Grain Inspection Service, U.S. Department of Agriculture. These grades are based on the proportions of damaged beans, weevil-bored beans, non-blackeye beans, foreign material, and off-color beans. Most transactions are based to some degree on these USDA grades. Generally, however, the actual graded certificates are only important for export or for government orders, or when there is a dispute over the quality of a given lot of beans.

Most blackeye beans are sold based both on the USDA grade and on samples submitted to the prospective buyer, and visual quality is a very important factor in marketing. Better-quality beans not only bring a higher price—the beans are generally more marketable because more consumers are willing to buy them.