Chapter 20

Insects and Other Bean Pests in Latin America

Aart van Schoonhoven and
César Cardona

Page

Chapter 20

Insects and Other Bean Pests in Latin America

Introduction

Pests take their toll of bean production as in any crop, both before and after harvest. Attempts to reduce these losses through pesticides have been relied upon less in bean production than in other crops. Bean production in Latin America occurs principally on small holdings where growers often have limited economic resources, conditions not conducive to programmed pesticide use. Moreover, beans often are grown in association with other crops, which may help to stabilize insect populations. While such factors favor an integrated approach to insect control, the short growing seasons and rapid crop turnover in beans may not suit a stable ecosystem, which is desirable for effective pest management practices.

This chapter reviews pertinent literature available on bean pests in Latin America, with emphasis on bean pest ecology and non-chemical control methods. Since the Latin American literature contains no information for some pests, references are cited from other regions on crops besides beans.

Ruppel and Idrobo (100) listed a total of 208 insect species which attack beans, while Mancía and Cortez (65) list more than 400 insect species which are found on bean plants. Bonnefil (6) considers 15 insect species to be economically important in Central America. Most bean pests are omnivorous, attacking several cultivated legumes or other crops. The most important bean pests reported in the literature and according to the authors' observations are listed in Table 1. The given division cannot be maintained strictly, since the Mexican bean beetle and chrysomelids also may attack young pods while *Epinotia* and *Heliothis* spp. may also attack leaves and buds. Not all pests listed are insects, such as slugs and mites.

Fig. 1- Geographical distribution of principal bean pests in Latin America.

Distribution of Important Insect Pests

The bean pest complex varies greatly throughout Latin America and is not well documented. However, Gutierrez *et al.* (43) reported that the leafhopper is the most widely distributed insect in Latin America, with chrysomelids (mainly *Diabrotica balteata*), cutworms, crickets, pod damaging insects (especially *Apion godmani*) and storage insects listed in decreasing levels of importance (Table 2). The authors gave no estimates of the economic importance of these pests. The leafhopper is the most important bean insect in Central America (6), followed in importance by the chrysomelids (Table 3).

A simplified distribution of the principal bean pests is shown in Figure 1. For example, the Mexican bean beetle occurs in Mexico, the Guatemalan highlands and Nicaragua. The bean-pod weevil (*Apion* spp.) still is a problem as far south as northern Nicaragua. Snails, not shown, are a severe problem to bean culture in El Salvador and Honduras.

Stored grain insects, *Acanthoscelides obtectus* and *Zabrotes subfasciatus,* are found in all areas of Latin America. *A. obtectus* occurs primarily in higher altitudes in both fields and warehouses in Chile, Argentina, Peru and Colombian mountains, while *Z. subfasciatus* is found primarily in beans stored at lower elevations.

Economic Losses

Potential loss from insect damage varies greatly between and among regions, due to differences in planting dates, cultivars and cultural practices. Miranda (81) reported insect losses of 33-83% when non-treated plots were compared to treated plots. Losses from *Apion* in El Salvador were 94% (67), although average losses are lower. In 16 insecticidal trials in Central America, controls yielded an average of 47% less than the highest yielding insecticidal treatment, with greatest losses inflicted by leafhoppers (Table 4). These figures probably over-estimate the importance of insects in bean culture, since such insecticidal trials normally are planted to coincide with the highest levels of insect attack. This was apparent in studies with Diacol-Calima, which is susceptible to leafhopper attack and which sustained losses of 14-23% (average 22%) during the rainy season, while dry season losses were 73-95%. The average loss was 76% (Fig. 2). Studies by

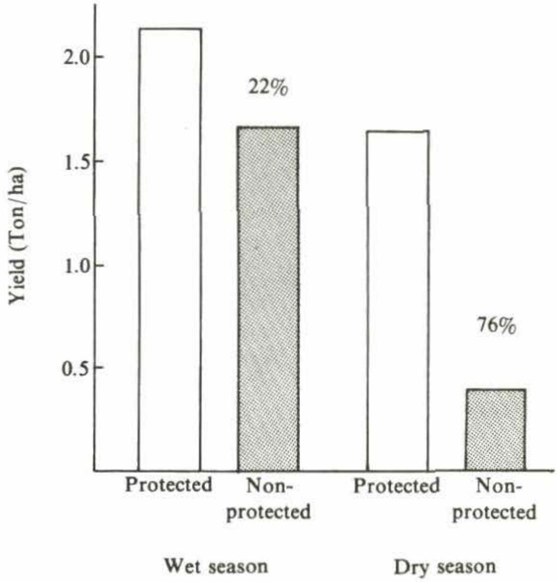


Fig. 2- Average yield of Diacol-Calima of best insecticidal treatment compared with nonprotected plots in wet and dry season (Ave. 3 trials in each season).

Pinstrup-Andersen *et al.* (87) in the Cauca Valley in Colombia estimated that *Empoasca kraemeri* caused an average 10.8% crop loss on 12,000 ha of beans grown in 1974, resulting in a loss of $749,000 in U.S. currency for that growing season.

Economic Threshold Populations

An important aspect of pest management is the level of damage that can be tolerated economically. Greene and Minnick (39) obtained a 37% yield reduction due to 25% defoliation one week before flowering, while 25-33% defoliation during flowering did not reduce yield. Results have shown that defoliations between 30 and 45 days after planting (beginning of flowering to end of flowering) were most damaging to yield (15). Yield losses greater than 35% occurred only when more than 60% of the foliage was removed. Leafhopper studies at CIAT (15) indicated a 6.4% yield loss occurred for each additional nymph present per leaf (Fig. 3). These data indicate that beans can withstand certain levels of defoliation before yield losses occur.

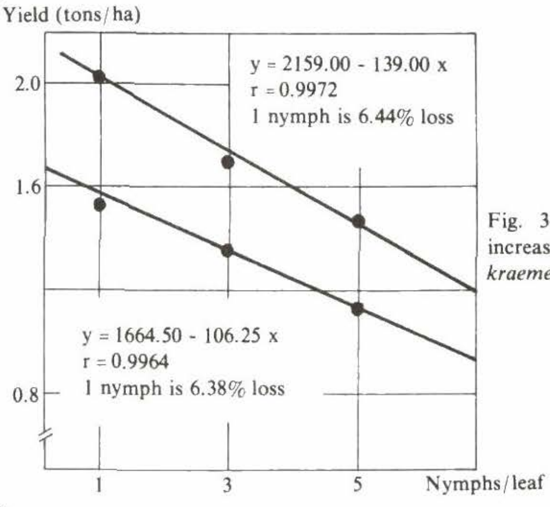


Fig. 3- Yields of dry beans at increasing populations of *E. kraemeri* nymphs.

Seedling-Attacking Insects

Seed Corn Maggot

Hylemya cilicrura (Rondani) (Diptera: Anthomyiidae).

The seed corn maggot is a bean pest in Chile, Mexico and areas of the United States and Canada. The genus has been named *Delia, Phorbia* and *Hylemya.* Other species reported on beans include *H. platura* and *H. liturata. H. cilicrura* and *H. liturata* are closely related (79), although McLeod (76) separated them by differences in nutritional requirements and infertility of interspecific hybrids.

Common names frequently used for the seed corn maggot in Latin America include mosca de la semilla, mosca de la raíz and gusano de la semilla.

Oviposition takes place near seeds or plants in the soil. Larvae feed on bean seeds (Fig. 4) or seedlings (Fig. 5) and pupate in the soil (79). Harris *et al.* (46) reported an incubation period of two days, a larval stage of nine days and a pupal stage of eight to 12 days at 21° - 23°C. Crops susceptible to larval attack include beans, maize, potatoes, beets, pepper, tobacco and other vegetables (79). The scientists also found evidence that above 24°C, pupae enter estivation. The average female produced 268 eggs.

Fig. 4- (above) Larvae of seed corn maggot, *Hylemya cilicrura* feeding on a bean seedling.

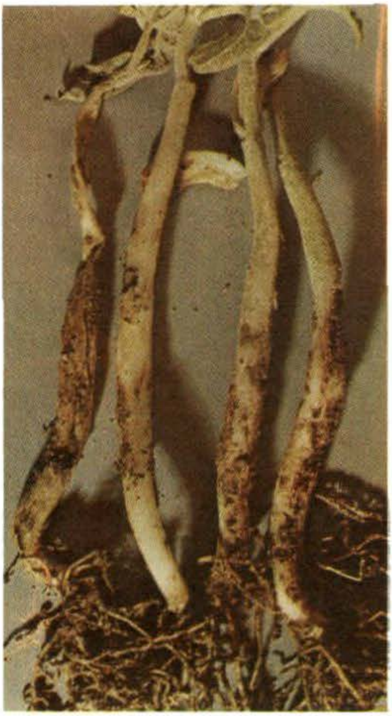


Fig. 5- (right) Damage caused by the seed corn maggot on bean seedlings.

Adult females (the adult fly resembles the housefly) were abundant on dandelion and aphid honeydew and were less active at temperatures higher than 32°C. Adults are attracted to newly disturbed soil and organic matter in which their larvae can develop, for example, in decaying spinach. Size of the adult population is not necessarily related to severity of seed damage.

Hertveldt and Vulsteke (50) report 20-30% germination loss when one or two larvae were present per bean seed, while two or three larvae reduced germination 50%. Damage includes poor germination and production of deformed seedlings (baldheads) and occurs when larvae feed between the cotyledons, thereby injuring the embryo. Larvae also can penetrate the stem of germinating seeds and damage young plants.

Late planting in Chile causes rapid seed germination and reduces exposure time to *Hylemya* spp. In three spring plantings at one month intervals the percentage of plants which germinated and were damaged by *Hylemya* spp. was reduced from 27 to 9 to 2%, respectively (C. Quiroz, personal communication). Humid soils with high organic matter were more likely to attract ovipositing females, especially if the field was recently plowed.

Biological control is reported to operate only at low levels and does not provide effective control (79).

Plant resistance to seed corn maggots is reported by Vea and Eckenrode (120). To insure the high larval population needed for screening, they planted during periods of high fly population and increased natural infestation by band-applying meat and bone meal. The bean lines C-2114-12 and P.I. 165426 showed 0 and 4% stand loss, respectively, while the susceptible cultivar Sprite had an 88% loss. The percentage of emerged seedling damage also was lowest for P.I. 165426 and C-2114-12. White-seeded cultivars were susceptible. Rapid emergence and hard seed coats contributed to resistance. Guevara (40) also reported differences in level of attack by *Hylemya* spp., and black-seeded cultivars were less damaged than yellow-seeded cultivars.

For many years, a combined Dieldrin + fungicide seed dressing was the standard treatment for control of *Hylemya* spp. (36). Repeated exposure of the maggot to chlorinated hydrocarbons has led to development of insect resistance to the chemical. Insecticides such as Diazinon, Carbofuran and Chlorpyrifos applied as granules in the furrow or as a seed slurry can control the larvae effectively (24). C. Quiroz (personal communication) obtained better control with Carbofuran than with Aldrin when applied as a granule at planting time in Chile.

Cutworms, Whitegrubs, Crickets

Many species of cutworms damage beans by causing stand losses as larvae sever the stems of young seedlings (Fig. 6). Older plants can be damaged by stem girdling (Fig. 7), which predisposes plants to wind breakage. Common cutworm genera include *Agrotis*, *Feltia* and *Spodoptera*. General biology and control of cutworms are discussed by Metcalf and Flint (78).

Fig. 6- Bean plant severed by a cutworm larva.

Fig. 7- Cutworm damage on an older bean plant.

Common names frequently used for cutworms in Latin America include trozadores, cortadores, nocheros, rosquillas, lagarta militar and lagarta rosca. Common names frequently used for whitegrubs include gallinaciegas, chizas and mojojoys. Common names frequently used for crickets include grillos and grillotopos.

Cutworm attack in beans occurs erratically and is difficult to predict. Therefore, it is better to control cutworms with baits applied in the late afternoon near the plants than to use the common preventive chemical control with Aldrin. A formulation of 25 kg sawdust (or maize flour), 3 liters molasses and 1 kg Trichlorfon per hectare also is effective in controlling crickets and millipedes.

In preliminary trials at CIAT, it appeared that beans were not a preferred host for *Spodoptera frugiperda,* which is one of the most important cutworm species. In associated cropping of beans with maize, cutworm damage in beans was nearly zero. Likewise, cutworm damage was significantly greater (71%) in maize monoculture than in maize associated with beans.

Whitegrubs (Fig. 8), mainly a problem in crops following pasture, can be controlled by proper land preparation. Chemical control is possible with Carbofuran or Disulfoton band-applied (0.9 kg a.i./ha) and with Aldrin incorporated into the soil.

Crickets and molecrickets also are listed as pests of beans (Fig. 9) in some countries (90), but they seldom cause significant economic losses.

Lesser Corn Stalk Borer

Elasmopalpus lignosellus (Zeller) (Lepidoptera: Pyralidae).

E. lignosellus is a serious bean pest in parts of Peru (F. Avalos, personal communication), Brazil (18) and other countries in Latin America. It attacks a variety of weeds and cultivated plants including maize, sugar cane, cereals, legumes and nutgrass.

Common names frequently used for the lesser corn stalk borer in Latin America include coralillo, barrenador del tallo, elasmo and lagarta elasmo.

Larvae (Fig. 10) enter the stem just below the soil surface and tunnel upwards (Fig. 11), causing plant mortality and subsequent stand loss. The adult oviposits eggs singly on the leaves or stems, or in the soil. The six larval instars are passed in 13-24 days, after which they pupate in the soil (59). Dupree (23) found little evidence of stem boring activity prior to the third instar.

Control is achieved with clean fallowing for prolonged periods or with heavy irrigation (11, 124). Leuck and Dupree (60) observed egg and larval parasitism by species of Tachinidae, Braconidae and Ichneumonidae on larvae collected from cowpeas. Chemical control should be started at planting time and granular insecticides should be directed near the seeds to kill larvae present in the soil.

Leaf-Feeding Insects

Chrysomelids

Many species of Chrysomelids attack beans in Latin America, the most prevalent genera (Fig. 12) being *Diabrotica, Neobrotica, Cerotoma* and *Andrector* (6). *D. balteata* LeConte probably is the most abundant species. Ruppel and Idrobo (100) list 36 species of Chrysomelids, including the additional genera *Epitrix, Chalepus, Colaspis, Maecolaspis, Systena* and others. This review will concentrate mostly on *D. balteata* (Fig. 13), the banded cucumber beetle.

Common names frequently used for chrysomelids in Latin America include crisomelidos, cucarroncitos de las hojas, diabroticas, doradillas, tortuguillas, vaguitas and vaguinhas.

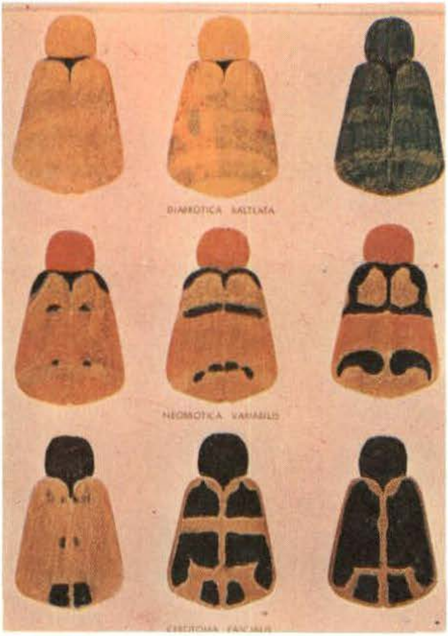
Fig. 9- Typical cricket damage on a bean plant.

Fig. 10- Mature larvae of the lesser corn stalk borer, *Elasmopalpus lignosellus*.

Fig. 11- (right) Damage caused by lesser corn stalk borer.

Fig. 12- (below) Color variation in adults of Chrysomelids.

Fig. 13- (lower right) Adult *Diabrotica balteata*.



Most damage by Chrysomelids occurs during the seedling stage (Fig. 14) when the insect consumes a relatively high percentage of foliage. Boonekamp (7) concluded that feeding by adult Chrysomelids has little effect on bean yield except when attack occurs during the first two weeks after planting or, to a lesser extent, during the flowering stage of the plants. Larvae also may damage bean roots and root nodules containing *Rhizobium* (nitrogen-fixing bacteria). Sometimes adults feed on young pods. Chrysomelids also are known to transmit bean rugose mosaic virus (29).

Females (one to two weeks old) oviposit eggs singly or in clusters of up to 12 eggs in soil cracks or beneath plant debris. An adult may lay more than 800 eggs during a lifespan of 17-44 days (average 26 days). Oviposition usually occurs at intervals of a few days. Eggs hatch in eight days at 21°C and six days at 27°C. The three larval stages are passed in 11 days on soybean roots at 27°C. Pupae form in a pupal cell in the ground, and this stage lasts seven days at 27°C (88). Young and Candia (130) reported an incubation period of five to nine days, a larval period of 17 days, and a prepupal-pupal stage of nine to 17 days. The maximum egg production by adults that fed on bean leaves was 144 per female. Pulido and López (91) found an average of 326 eggs produced when adults were fed only soybean leaves and 975 eggs when adults were fed soybean leaves, flowers and young pods. When fed soybean leaves, adults lived for 69-112 days. Harris (48) observed adult color variation within *D. balteata* and especially within *Cerotoma facialis* (Erichson).

While adults feed on many plants including maize (silk and pollen) and beans (leaves), the larvae may develop on roots of maize, beans (Fig. 15) and other crops. Pulido and López (91) list 32 host plants. Of these, maize and beans with five other plant species are listed as hosts for adults and larvae. Harris (48) reported that common bean-field weeds in the Cauca Valley serve as larval hosts and include *Amaranthus dubius, Leptochloa*

Fig. 14- Severe damage caused by adult Chrysomelids.

Fig. 15- Larval damage of *Cerotoma facialis* on bean hypocotyl.

filiformis, Echinochloa colonum and *Rottboellia exaltata*. He found *D. balteata* and *C. facialis* adults preferred beans rather than soybeans, peanuts, cotton or maize. Larvae of *D. balteata* can be reared on maize but not on bean roots, while those of *C. facialis* can be reared on beans but not on maize roots (7). Young (129) reported that in Mexico *D. balteata* adults have a feeding preference for young bean plants and an oviposition preference for young maize plants. When bean and maize were grown in association, *C. facialis* larvae had a high preference for bean roots and *D. balteata* larvae for maize roots (7).

Fig. 16- Adult Reduviid preying on an adult Chrysomelid.

Predation of adult chrysomelids by Reduviids (Fig. 16) often is observed in the field. Young and Candia (130) reported a Tachinid occurred as an adult parasite. Chemical control often is recommended with Carbaryl, Malathion or Dimethoate.

Lepidopterous Leaf Feeders

Several species of Lepidoptera develop on beans. Although larvae commonly are found on beans, populations usually are too low to cause economic damage.

Bean Leafroller

Urbanus (= Eudamus) proteus (L.) (Lepidoptera: Hesperiidae).

The bean leafroller is distributed widely on beans from the United States to Brazil. Greene (37) calculated that yield reduction occurred when more than 725 cm^2 leaf area per plant was destroyed.

Common names frequently used for the bean leafroller in Latin America are gusano fósforo and gusano cabezón.

Although the first three larval stages of the leafroller do not cause appreciable damage, the fourth can reduce yield when more than 26 larvae

Fig. 17- Bean leaf folded by young larva of the bean leafroller.

occur per plant. The fifth instar consumes about 162 cm^2 of leaf area, and economic losses occur when an average of four larvae eat 33% of the total leaf area. Assuming 50% mortality per instar, 141 eggs per plant (a population level seldom observed) would be required to cause significant damage.

The butterfly lays one to six eggs per lower leaf surface. Young larvae then fold and tie a small section of the leaf margins together (Fig. 17) within which they live and pupate. However, often they may feed elsewhere. Larvae are easily recognized by their three dorsal longitudinal lines and larger red-brown head capsule (Fig. 18) (92). Greene (38) reported that in the field only 4% of the eggs reached the fifth instar. At 29.5°C eggs hatched in three days, the larval stage was passed in 15 days and the pupal stage passed in nine days. He observed large numbers of adults on *Lantana camara* flowers and in flowering bean fields. Van Dam and Wilde (119) studied its life cycle in Colombia and found that the egg stage lasted an average of four days while the larval and pupal stages required 23 and 11 days, respectively, to develop. Larvae have been found frequently on beggar weed *(Desmodium tortuosum)* and other *Desmodium* species (92).

Chemical control seldom is justified and natural control by parasites and predators is commonly observed. In Colombia, for example, larval parasitism ranged from 21 to 40% during a one-year study (119).

Fig. 18- Mature larva of bean leafroller, *Eudamus proteus*.

Saltmarsh Caterpillar

Estigmene acrea (Drury) (Lepidoptera: Arctiidae).

The saltmarsh caterpillar, although commonly found on beans, usually is recognized as a pest of cotton, lettuce and sugarbeets (110). Young and Sifuentes (131) report preferred natural hosts include *Amaranthus palmeri* and *Physalis angulata*. The pest also occurs on maize, horticultural crops, soybean, sesame, tobacco, cotton and several weed hosts.

The common name frequently used for the saltmarsh caterpillar in Latin America is gusano peludo.

The adult moth places egg masses of up to 1000 eggs on *A. palmeri,* and larvae develop in 17-19 days. The young larvae aggregate (Fig. 19) and can skeletonize isolated bean plants. Older larvae are solitary, their bodies are covered with setae (Fig. 20), and they pupate on the soil in plant debris. The adult is a white moth with black dots on its wings (131).

Individual plants on which the gregarious stages are passed may be damaged severely, although beans seldom suffer economic damage. In the Cauca Valley in Colombia, 12 Dipterous species caused an average 31% parasitism on larvae (96). Young and Sifuentes (131) reported that coccinellids and malachiids are egg predators, and reduviids are larval predators. Several hymenopterous parasites of larvae also have been reported. Chemical control is seldom justified.

Fig. 20- (above) Mature larva of *Estigmene acrea.*

Fig. 19- (left) Young larvae of the saltmarsh caterpillar aggregated on a bean leaf. Older larvae are solitary.

Hedylepta

Hedylepta (= Lamprosema) indicata (Fabr.) (Lepidoptera: Pyralidae).

H. indicata is a pest of beans, soybeans and other legumes in South America (32, 100). The common name frequently used for *Hedylepta indicata* in Latin America is Hedylepta.

Fig. 22- (above) Mature larva of *Hedylepta indicata.*

Fig. 21- (left) Leaf-feeding damage by *Hedylepta indicata* larva.

Adult moths oviposit on the lower surface of leaves, where a female lays an average of 330 eggs. The eggs hatch in four days, the green larvae (Figs. 21 and 22) develop in 11 days, pupate (Fig. 23), and five days later the adult emerges (52). Larvae feed on the parenchyma of leaves which they weave together (Fig. 24). Therefore, they are protected from exposure to insecticides.

The level of biological control is high. García (32) found more than 85% larval parasitism by *Toxophroides apicalis* (Hymenoptera: Ichneumonidae). A carabid predator of *H. indicata* larvae passes its entire life cycle between the leaves woven together by *Hedylepta* (57). Chemical control is most effective with Methamidophos and Dicrotophos (30), but their use is seldom justified.

Fig. 23- Pupa of *Hedylepta indicata* among leaves woven together by the larva.

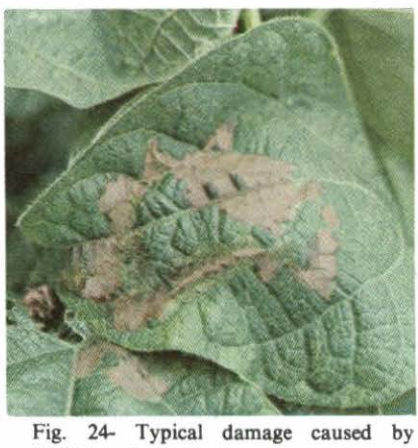


Fig. 24- Typical damage caused by *Hedylepta indicata.*

Mexican Bean Beetle

Epilachna varivestis Mulsant (Coleoptera: Coccinellidae).

The Mexican bean beetle is mainly a soybean pest (118), but beans have been damaged in the United States, Mexico, Guatemala and El Salvador (in the latter during the wet season). It differs in behavior from most coccinellids in that larvae and adults feed on foliage, stems and young pods, whereas the family is more commonly predaceous. Synonyms include *Epilachna corrupta* Mulsant and *E. maculiventris* Bland.

The common name frequently used for the Mexican bean beetle in Latin America is conchuela.

In El Salvador, *Phaseolus vulgaris, P. lunatus, P. atropurpureus, Vigna sinensis* and *Glycine max* are hosts (65) while beggarweed also is reported to be a host. Turner (116) reared the beetle on *P. vulgaris, P. coccineus, P. lunatus, V. sinensis* and *Dolichos lablab;* high larval mortality occurred on the latter. He classified *P. aureus* and *Vicia fabae* as immune. *P. aureus, P. mungo* and *P. radiatus* are less preferred hosts than *P. vulgaris* (4, 127). This preference is attributed mainly to the sucrose concentration which serves as an arrestant combined with differences in olfactory action of the foliage (4). LaPidus *et al.* (54) confirmed these results in studies of seeds from resistant and susceptible plants.

Young larvae feed on the lower leaf surface and usually leave the upper epidermis undamaged, while older larvae (Fig. 25) and adults (Fig. 26) often feed over the entire leaf. Third and fourth instar larvae consume more than adults. Stems and pods often are eaten if high population densities exist. The larvae do not chew the leaf tissue, but scrap the tissue, compress it and then swallow only the juices. De la Paz *et al.* (21) concluded that most

Fig. 25- Mature larva of Mexican bean beetle.

Fig. 26- Adult Mexican bean beetle on lower surface of a bean leaf.

damage occurred when young plants were infested. Infestation of 41-day old plants with 25 larvae each, reduced yield 93% more than delaying infestation to 71 days after planting.

The adult female beetle begins oviposition seven to 15 days after copulation and lays yellow to orange-colored eggs on the lower leaf surface in groups of four to 76 (average 52) (100). Mancía and Roman (66) obtained an average of 10 egg batches with 36-54 eggs per batch (average 43). Eggs hatch in six days, the four larval instars are passed in 15-16 days, the prepupal stage in two days and the pupal stage in six or seven days. The yellow larvae are covered with branched spines. Pupation occurs with larvae attached to the lower leaf surface. Adults are copper colored with 16 black spots and live four to six weeks. In El Salvador, the beetle passes four generations on beans from May to November. In the United States, adults hibernate in woodlands and bean debris and are often gregarious (25).

Predators of eggs and the first larval instar include *Coleomegilla maculata* De Geer and *Hippodamia convergens* Guenée. Adults are attacked by the mite, *Coccipolipus macfarlanei* Husband (66), and *C. epilachnae* Smiley also is observed in El Salvador (108). *Pediobius faveolatus* (Crawford) (Hymenoptera: Eulophidae) reduced Mexican bean beetle populations on soybeans (109).

Removal of plant debris and deep plowing are recommended to control the insect. Reduced plant density decreases beetle injury, as egg mass numbers per plant decreased from 1.07 to 0.15 when plant spacing was increased from 5 to 12 cm. Yield reduction was decreased from 23 to 11%, and pod damage also declined (117).

Plant resistance to the Mexican bean beetle has been studied in some countries. In free-choice cage studies on 60 bean and lima bean cultivars, Idaho Refugee and Wade were resistant, losing only 25% foliage, while Bountiful had 62% of the foliage destroyed. The number of eggs and egg masses and adult weights were reduced more than 50% when beetles were reared on resistant versus susceptible lines (10). Wolfenbarger and Sleesman (127) did not observe resistance in *P. vulgaris* material they investigated. They tested Idaho Refugee and Wade and rated them susceptible (8.5 on a 1-9 scale, with 9 most susceptible). Based on leaf feeding damage, the highest level of resistance was found in *Phaseolus aureus*. Nayar and Fraenkel (82) hypothesized that phaseolunatin (a cyanogenic glycoside) attracts beetles when present in low concentrations but may be responsible for resistance in germplasm containing high concentrations of this compound. The entries Puebla 84 *(P. coccineus),* Guanajuato 18 and Zacatecas 48 *(P. vulgaris)* were resistant (31). Fewer eggs were laid on Gto. 18 and Oax. 61-A. They concluded that antibiosis and non-preference were responsible. More recently, Raina *et al.* (93) found that the cultivars Regal (snapbean), Baby Fordhook (lima) and Baby White (lima) had less than 40% leaf damage and suffered significantly less from attacks than other cultivars tested. Raina *et al.* (93), Thomas (113), Wolfenbarger and Sleesman (127), and Campbell and Brett (10) concluded that lima beans as a group were less preferred than snapbeans.

Cadena and Sifuentes (9) obtained effective chemical control with Carbaryl. Malathion and Methyl Parathion were much less effective. They suggested the first application be made when 25 adults/ha were present, the second application be combined with *Apion* spp. control and a third application be made only if needed. Recommendations in the United States are that farmers spray when one beetle or egg mass is found per 6 foot (1.8 m) row. The beetles are counted on the ground after shaking the plant. Hagen (44) obtained an effective 10-week control with a planting application of insecticides such as Disulfoton, Carbofuran, Phorate, Aldicarb and Fensulfothion.

Piercing Insects

Leafhoppers

Empoasca kraemeri Ross and Moore (Homoptera: Cicadellidae).

E. kraemeri is the most important insect pest of beans. It occurs from Florida and Mexico south to Ecuador and Peru. *E. fabae* and *E. solanae* occur in the United States and Canada but not in South America (97). Other *Empoasca* species in South America include *E. prona, E. aratos* and *E. phaseoli* (6).

Common names frequently used for leafhoppers in Latin America include Empoasca, chicharritas, lorito verde, cigarra, saltahojas and cigarrinha verde.

E. kraemeri does not transmit virus diseases, the only *Empoasca* species known to have this attribute being *E. papayae,* which transmits bunchy top virus of papaya. The only leafhopper known to transmit a bean virus (bean curly top) is the beet leafhopper, *Circulifer tenellus*.The brown leafhopper, *Scaphytopius fuliginous* Osborn, transmits a mycoplasma-like organism to beans and soybeans in Colombia (Refer to Chapter 11).

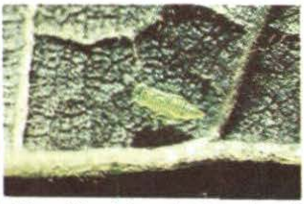


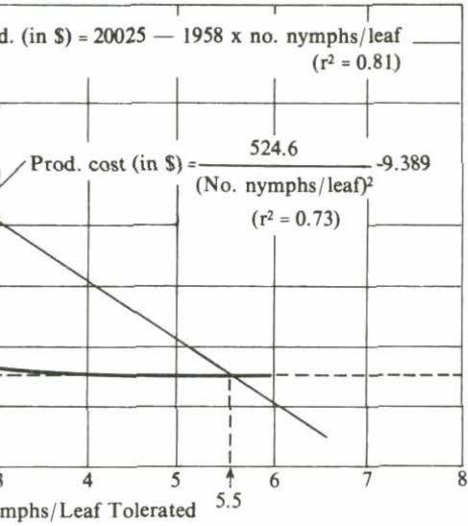
Fig. 28- (above) Nymph of *Empoasca kraemeri*.

Fig. 27- (left) Adults of *Empoasca kraemeri*.

Eggs of *E. kraemeri* hatch in eight or nine days, and the five nymphal instars are passed in eight to 11 days (123). Females and males (Fig. 27) live for 65 and 58 days, respectively. Oviposition ranged from 13-168 eggs (average of 107) per female. The eggs are commonly laid singly on leaf blades, petioles, leaf tissue or stems of bean plants; 50-82% of the eggs laid per plant may be located in the petioles (34). Leafhoppers breed on many cultivated and non-cultivated plants. *Empoasca* spp. nymphs (Fig. 28) have been collected from more than 80 plant species in Colombia.

Plant damage may be caused by physical feeding injury in phloem tissue, although a toxin also may be involved. Plant damage appears as leaf curling and chlorosis, stunted growth (Fig. 29), greatly reduced yield (Fig.

Fig. 29- Typical leaf curling and yellowing damage caused by leafhopper feeding.



leafhopper nymphal population, production and

fhopper attack is more severe during hot dry fficient soil moisture. Furthermore, damage ppers *(E. fabae)* is less during humid weather re stress (5). Miranda (80) obtained yields of ere planted December 21, but only 121 kg/ha uary 21 in El Salvador. It is assumed that high aggravate *Empoasca* spp. damage, especially ions of 1000-1500 m (99). Screening at CIAT ance usually is made during dry or semi-dr tions are highest (14). However, plantings y season sometimes remain relatively free of lected at this time caused less damage than

s often can be manipulated to reduce damage. Maize has reduced populations of ans were planted in association. Leafhopper nificantly in plots where maize was planted 20 s per 90 bean plants) as compared to fields planted on the same day (133 adults per 90 m *(Spodoptera frugiperda)* populations also n fields where beans were planted 20 days r 40 maize plants), compared to fields where ed on the same day (26 larvae per 40 maize

Leafhopper adult and nymphal populations were decreased 43 and 70%, respectively, in bean plots with nearly 100% weed cover (16). This reduction in *Empoasca kraemeri* populations was not ascribed to increased parasite or predator populations. Bean yields were comparable in weed-free and weedy plots, the decrease in leafhopper populations being counterbalanced by the increased weed competition (17). Leafhopper populations also were significantly reduced in bean plots surrounded by borders (1 m wide) of grassy weeds such as *Eleusine indica* and *Leptochloa filiformis*.

Mulching and shading also reduced initial *Empoasca kraemeri* populations. Only 18 insects were collected from mulched plots at 20 days after planting, whereas non-mulched plots yielded 103 adults. By 45 days after planting, the beans in the mulched plots were more vigorous than those in the non-mulched plots wherein the leafhopper populations were then highest (16).

Varietal resistance to leafhoppers in beans was reported in the United States for Wells Red Kidney (5) and other materials (71). Idaho Refugee and U.S. Refugee No. 5 are resistant to leafhopper damage by *E. fabae* and *E. kraemeri* (15, 33). Tissot (114) observed equal leafhopper population levels on resistant and susceptible cultivars, which is consistent with results obtained at CIAT.

In the United States, Wolfenbarger and Sleesman (125, 126) evaluated 1619 lines for resistance to *E. fabae* and found that P.I. 151014 had 0.3 nymphs per leaf (lowest count), while Dutch Brown had 19.7 nymphs per leaf (highest count). They found no correlation between number of epidermal hairs and nymphal population per cultivar but reported a 90-96% correlation between nymphal counts and damage estimates (125). A relationship did exist between leafhopper resistance and plant characteristics such as tallness, resistance to BCMV, pink or mottled-colored seed and intermediate maturity (125). The lowest nymphal counts were obtained on *Phaseolus lunatus, Phaseolus aureus* and *V. mungo*. There are barriers to crossing these species with *P. vulgaris*. However, results from interspecific crosses between *P. vulgaris* and *P. coccineus* suggest that resistance may be recessively inherited (128). Chalfant (12) reported a 50% yield reduction when protected and unprotected plots were compared, regardless of the degree of varietal susceptibility.

A major screening program for varietal resistance to *Empoasca kraemeri* has been inititated at CIAT (Fig. 31) where more than 8000 *P. vulgaris* accessions have been tested to date. The selection scheme is based on elimination of highly susceptible materials. Ten test cultivars are planted between rows of ICA-Tui (standard tolerant cultivar). Diacol-Calima or

Fig. 31- Susceptible (left) and resistant (right) entries after exposure to *Empoasca kraemeri*.

ICA-Bunsi are planted around the plot as a susceptible border. ICA-Tui always is rated as grade 2 in a 0-5 damage scale. In wet season plantings, the most resistant bean materials identified yield equally with or without insecticidal protection, while susceptible cultivars suffer losses of up to 40%. Such resistance levels have given adequate protection against *Empoasca* in Peru. However, in the dry season at CIAT, even these materials require insecticidal protection. A breeding program is underway to increase resistance levels within commercially acceptable cultivars.

Correlations have not been obtained at CIAT between nymphal counts and damage scores as reported by Wolfenbarger and Sleesman (125) and Chalfant (12). Populations of the insect are much higher at CIAT than in the United States and susceptible cultivars receive so much damage that leafhoppers avoid them for oviposition (15).

The resistance mechanism is not clearly understood, but tolerance is probably responsible. ICA-Tui has a low degree of non-preference which is lost during no-choice tests. Antibiosis has not been found to be present (122). Hooked trichomes can capture nymphs and may be another resistance mechanism (86). Nymphal mortality of *E. kraemeri* was low on hooked trichomes in studies at CIAT and may be due to decreased trichome density on expanded leaves. By the time leafhopper eggs hatched, the leaves in which they were laid were fully expanded and the trichomes were less dense.

Two egg parasites (*Anagrus* sp. and *Gonatocerus* sp.) and a diyinid nymphal parasite have been reported as natural enemies of *E. kraemeri,* but they do not seem to be very effective. Thus, Gómez and Schoonhoven (34) concluded that in spite of high levels of parasitism (60-80%), *Anagrus* sp. was unable to keep the pest populations below acceptable levels.

Chemical control of leafhoppers is obtained by a variety of products. Foliar sprays of Carbaryl (1 kg a.i./ha) and Monocrotophos (0.5 kg a.i./ha) are effective. Granular soil-applied Carbofuran (placed under but not in contact with the seed) at 0.7 - 1.0 kg a.i./ha protected plants for 30-40 days, while 0.6 - 0.7 kg a.i./ha of Carbofuran seedcoated also gave excellent control (14, 16).

Whiteflies

Five species of Aleyrodids live on beans in the Americas. They are *Bemisia tabaci, B. tuberculata, Tetraleurodes acaciae, Trialeurodes abutilonae* and *T. vaporiarorum*. These species also have other leguminous and non-leguminous hosts.

Common names frequently used for whiteflies in Latin America are mosca blanca and mosca branca.

B. tabaci (Gennadius) is a vector of bean virus diseases such as bean golden mosaic (BGMV) and bean chlorotic mottle. The insect species has a wide range of synonyms. Some race identifications are based upon their virus transmission characteristics. Whitefly feeding does not damage bean plant development directly but does so indirectly when a virus is transmitted.

Eggs are laid singly or in groups on the lower leaf surface where the egg pedicel is inserted into the epidermis. The egg to adult stage requires about three weeks. Oviposition ranges from 25-32 eggs per female. The three immature stages and pupal stage occur on the lower leaf surface (Figs. 32 and 33). Identification is made on the immature stage (101).

In Guatemala, large differences exist according to geographical zone and planting date (3) for intensity of attack by whiteflies. Chemical control is

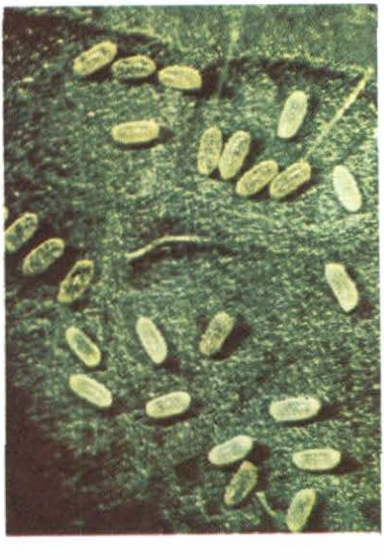


Fig. 32- (left) Eggs of whiteflies.

Fig. 33- (below) Pupa of *Trialeurodes* species.

most effective (measured as reduction of percent BGMV infested plants) with Metasystox or Oxydemeton-methyl and Monocrotophos (foliar application 15 and 30 days after planting), or Thimet or Phorate and Carbofuran granular application during planting (3). In El Salvador, Mancía *et al.* (68) report good control was obtained with the systemic granular insecticides Aldicarb, Carbofuran and Phorate.

Aphids

Several aphid species attack bean plants. Their direct damage is assumed to be of little importance, but their ability to transmit bean common mosaic virus makes them important pests economically. Further details are related by Zaumeyer and Thomas (133) and elsewhere in this book.

Common names frequently used for aphids in Latin America include afidios, pulgones, afidios and pulgao do feijoeiro.

Zaumeyer and Thomas reported the following aphids capable of transmitting bean common mosaic virus: *Aphis gossypii, A. medicaginis, A. rumicis, A. spiraecola, Brevicoryne brassicae, Hyalopterus atripilicis, Rhopalosiphum pseudobrassicae, Macrosiphum ambrosiae, M. solanifolii, M. pisi* and *Myzus persicae*. Costa and Rossetto (18) report aphids occur on bean foliage and roots in Brazil. In CIAT, control of bean common mosaic is sought by incorporation of genes which are resistant to the virus.

High aphid mortality occurs when insects are captured by hooked hairs on bean leaves. Capture percentage and number of hooked hairs increased when plants were grown under dry conditions, compared to when they were grown under ample moisture (28). A similar relationship was reported by McKinney (75) for *Myzus persicae* and thrips.

Thrips

Thrips have been found as pests of beans in several Latin American countries, but their attacks may not have much economic importance. *Frankliniella* sp., *Sericothrips* sp. and *Caliothrips braziliensis* (Morgan) have been reported in Brazil (98) and Colombia (90), where *C. braziliensis* is the most abundant species. Common names frequently used for thrips in Latin America are trips and bicho candela.

Larvae and adults feed on the undersurface of the cotyledonary leaves of seedlings. In older plants they also can be found feeding on leaves, flowers and petioles. When populations are high, thrips cause reduction in the size

Fig. 34- Damage caused by thrips on young bean plant.

and development of young plants (Fig. 34). In general, they seldom become an economic pest. Most attacks are localized towards the borders of the field and usually occur in hot, dry weather.

Females insert their eggs in the leaves, petioles and stems. In laboratory studies at CIAT, the eggs of *C. braziliensis* hatched in five to six days. The first larval instar lasted one or two days and the second instar four or five days. Pupation occurs in the soil and debris. The pupal stage took from two to three days to develop. Longevity and fecundity of the adults of this species have not been studied.

Chemical control is seldom justified. Adults and nymphs of *Orius tristicolor* are common predators of *Sericothrips* sp. and *C. braziliensis.*

Pod-Attacking Insects

Bean Pod Weevil

Apion godmani Wagner (Coleoptera: Curculionidae).

A. godmani is a serious bean pest in Central America where Mancía *et al.* (67) report up to 94% bean loss in El Salvador, especially during the rainy season. The bean pod weevil is considered the most serious bean pest in certain regions of El Salvador. The weevil also is of importance in Mexico, Guatemala, Honduras and Nicaragua and has been reported on beans in Colombia (1).

Common names frequently used for the bean pod weevil in Latin America are picudo de la vaina and picudo del ejote.

The weevil is prevalent especially in the highland, central and southern regions of Mexico during the rainy season (74), where up to 90% of the crop may be destroyed (26). In Mexico, *A. aurichalceum* is second in importance to *A. godmani.* The oviposition behavior of the former species is different since the female lays about 35 eggs in the distal portion of a pod, allowing the other seeds of the pod to escape attack (74).

Several other less important *Apion* species also attack beans and include *A. aurichalceum, A. perpilosum, A. calcaratipes, A. germanum, A. griseum* and *Chalrodenus aenerus. A. godmani* also has been called *Trichapion godmani* (62, 74). Other host plants include *Dalea, Desmodium, Rhynchosia* and *Tephrosia* spp. (73).

The adult weevil is black and about 3 mm long. During the wet season, two generations may be formed, with possibly a third occurring during the dry season. Overwintering sites could not be located in Mexico (74). Under laboratory conditions of 20.8°C and an average 75% relative humidity, Mancía (62) stated that the egg stage of the weevil lasts five days. The three larval instars are passed in six days, while the prepupal and pupal stage last two and nine days, respectively. The adult insect can remain three or four days in the pupal chamber but usually emerges immediately after pupation. Adult longevity may extend from 10 days to nearly a year (62), and adults may mate several times. Mancía (62) reported a maximum of 392 eggs were laid by each female, with four to six eggs laid per day. The preoviposition period lasted 10 days with a 12-day incubation period, 22-34 day larval stage, two-day prepupal stage, six to 10-day pupal stage and a two to three-month adult stage.

Adults appear when bean plants are still small and occasionally cause light feeding damage to leaves, pods and flowers. Oviposition damage occurs in the newly formed pods. During the daytime the female adult chews a small hole in the mesocarp of 1-4 cm long pods, usually above the developing seed, and deposits an egg. These spots are visible as white hyperplastic deformations (Fig. 35), and later the adult exit-holes from the pod wall also can be found (73, 74). Young pods which are attacked may abort (26).

Fig. 35- Hyperplastic deformations caused by ovipositing females of *Apion*.

Fig. 36- Damage caused by larva of *Apion* in bean pod.

Larvae in the second instar stage bore into the mesocarp of the pod wall (Fig. 36) and begin feeding on the developing seed, leaving the hylum intact. One larva per seed is normal. However, three to five larvae per seed have been found during heavy infestations, with a maximum of 22 larvae present in a pod (62). McKelvey *et al.* (73) normally found one larva per seed and a maximum of seven per seed and 28 per pod. Larvae live in a feeding chamber and cannot feed on mature seed (73).

Mancía (62) found two Braconid parasites of *Apion* larvae, one of which belongs to the genus *Triaspis*. McKelvey *et al.* (73) found no influence of planting date on level of infestation, although there was a tendency for lower infestations in early and late plantings.

Guevara (41) tested six cultivars for resistance and found that 4% of Pinto 168 bean seed was infested, while 67% of Negro Mecentral bean seed was infested. Puebla 152 (17% infestation) and Mexico 228-7 (12% infestation) were intermediate in resistance. Pinto 168 yielded equally well with or without chemical protection, Puebla 152 and Mexico 228-7 required two sprays, and the susceptible test cultivar Negro Mecentral required three or four applications to control the weevil.

Ramírez *et al.* (95) tested 14 cultivars and found Negro 151 was the most resistant with 84 *Apion godmani* larvae per 60 pods. Resistant Bayo 164 and Pinto 168 had 90 and 108 larvae per 60 pods, respectively. Canocel was the most susceptible cultivar with 806 larvae per 60 pods and the highest adult count per pod. Ranked in descending order, Negro 151, Chapingo 55-111-7, Pinto 168 and Amarillo 154 had fewer adults. Mancía (61) tested 2004 *P. vulgaris* entries for resistance to *Apion* spp. and obtained nine highly resistant cultivars and two less resistant but did not identify them. Highly resistant entries had 1-5% seed damage, while the most susceptible entry had 43-94% seed damage.

After four years of testing, McKelvey *et al.* (74) report the cultivars Puebla 152, Hidalgo 6, Puebla 2, and Hidalgo 24 consistently had lower infestations than others tested. Other resistant cultivars included Puebla 32-A-2 and 20-B-2; Hidalgo 33-A-1, 28-A-2, 38-A-1 and 14-A-3; and Gto. 3-A-2 and 10-A-5. Guevara (40) evaluated *Apion* spp. resistance in Mexico and resistant sources (based upon percent seed infested in 100 pods) included Pinto 162 and 168; Amarillo 153, 154 and 155; EAP 88B and Negro 151. Later, Hidalgo 15A and 24; Puebla 2 and 57-B-3; Tlax. 2-1-C; Amarillo 156 and 164; and Negro 157 were added (42). Resistance to *Apion* spp. was incorporated in crosses involving Hidalgo 6 and Puebla 32. Although no details are given on the resistance mechanism or mode of inheritance, highly resistant lines were obtained in crosses between Puebla 2 x Hidalgo 12-A-1, Hidalgo 12-A-1 x Puebla 32 and Zacatecas 4A-2 x Hidalgo 6-1. Medina and Guerra (77) tested 14 cultivars and found Negro 66, Jamapa, Canario 101 and 107 were resistant to *Apion* spp., *Empoasca* spp. and the Mexican bean beetle. Ojo de Cabra and Negro Criollo were resistant to *Apion* spp. and *Empoasca* spp. Bayomex, Delicia 71 and Querétaro 183-1 were resistant only to *Apion* spp. Mancía (61) states that immunity to *Apion* spp. exists in *Phaseolus coccineus (= P. multiflorus).* However, in a recent study, Yoshii (132) did not find a significant difference in Apion attack between *P. vulgaris* and *P. coccineus.*

Although future use of resistant cultivars holds great promise, chemical control still remains important. Several products have been tested and Monocrotophos, Methomyl, Methyl Parathion and Carbaryl give effective control. Granular Carbofuran applied at planting (2.5 kg a.i./ha) gave the best control (63). Methyl Parathion gave adequate and economic control when applied as a spray six days after flower initiation and again seven days later. A single spray was effective if applied 13 days after flower initiation (69).

Corn Ear Worm

Damage by the *Heliothis* complex, *H. zea* (Boddie) and *H. virescens* (F.) (Fig. 37), is sporadic but can be severe. Common names frequently used for the corn ear worm in Latin America include Heliothis, helotero, bellotero and yojota.

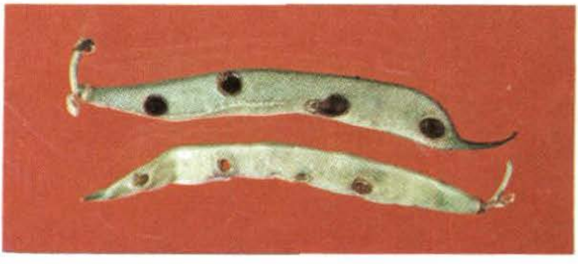


Fig. 37- Severe damage caused by *Heliothis* species.

The adult oviposits on young leaves, and larvae (Fig. 38) feed on seeds by perforating the podwall above the seed. Several seeds per pod may be destroyed, and secondary rotting can destroy the remaining seeds. It is not clear which of the two species is most common in beans. However, during a severe attack at CIAT only *H. virescens* was found.

Chemical control of older larvae is difficult, but high levels of parasitism usually occur. Posada and García (89) list 26 different parasite or predator species of *Heliothis* spp. in Colombia. In a CIAT study, 89% of field collected larvae were parasitized by a Tachinid fly. Recent findings also indicate that pyrethrins at low dosages effectively control *Heliothis virescens* larvae.

Other Pod-Boring Insects

Epinotia

Epinotia opposita Heinrich (Lepidoptera: Olethreutidae).

E. opposita is an important insect pest in Peru and Chile (124). Common names frequently used for *Epinotia opposita* in Latin America include polilla del fríjol and barrenador de la vaina.

Its larvae feed on or in the terminal buds, and/or perforate the stems and pods. Larvae weave their excrement together and push it out of the feeding canals. The insect also may cause flower damage and abortion. Bud and stem deformations occur after larval attack (Fig. 39), and pod damage can result in rotting by secondary organisms (2). In alfalfa, young larvae web leaves together and live therein. Other host plants include soybeans, peanuts, peas, cowpeas, lentils and clover (124).

Fig. 38- Larva of *Heliothis* species feeding on bean pod.

Fig. 39- Bud deformation caused by larval feeding of *Epinotia opposita*.

About four days after copulation, females oviposit an average of 110 eggs in four to eight egg masses during a period of one or two weeks. Eggs are laid on young plant tissue. The egg stage lasts four and seven days during summer and winter, respectively, and during these corresponding seasons the five larval stages are passed in 14 and 23 days. Pupation occurs in a cocoon on the leaves or the ground (124). Adults live 15-22 days and are active at night.

Wille (124) observed a Tachinid larval parasite *(Eucelatoria australis)* which pupates in the host pupal skin. Avalos (personal communication) tested nearly 200 cultivars for *Epinotia opposita* resistance and found large differences in percentage of terminal buds and pods attacked. Adequate chemical control was obtained with Aminocarb, Toxaphene + Methyl Parathion or Omethoate (115). Early spring plantings reduced percentage of pod damage by *Epinotia* to 4%, as compared with 72% damage in late spring plantings (C. Quiroz, personal communication).

Laspeyresia leguminis

Laspeyresia leguminis Heinrich. (Lepidoptera: Olethreutidae).

L. leguminis attacks beans, soybeans, broad beans and lima beans (1, 124). The common name frequently used for *Laspeyresia leguminis* in Latin America is Laspeyresia.

Its damage often is confused with that caused by *Epinotia opposita.* However, unlike *Epinotia opposita,* it may web pods together (Avalos, personal communication). Adults oviposit on pods where young larvae bore into them and destroy the seeds. The larva pupates in the pod (124). Control is similar to that of *Epinotia opposita.*

Maruca

Maruca testulalis (Geyer) (Lepidoptera: Pyralidae).

M. testulalis is reported to occur in Brazil (100), Colombia (90), Cuba, Puerto Rico (58) and Africa (112). Like most of the other podborers, *M. testulalis* oviposits near or on flower buds, flowers, young leaves and pods. The common name frequently used for *Maruca testulalis* in Latin America is gusano perforador de la vaina.

Damage to leaves and flowers occurs prior to podboring-type feeding (106). The insect may attack several species of legumes (58). According to Broadley (8) larvae pass through five instars in eight to 13 days at 25° - 29°C. Pupation occurs in the soil.

M. testulalis is distinguished from *Etiella zinckenella* (the lima bean podborer) by larval and adult coloring. *Maruca testulalis* larvae have four black or dark gray spots on each segment and adults rest with wings outspread. Larvae of *M. testulalis* expulse frass from the pods, while those of *E. zinckenella* leave it in the pod (111).

Storage Insects

Bruchids

The principal pests of stored beans are *Acanthoscelides obtectus* (Say) and *Zabrotes subfasciatus* (Boheman). Synonyms of *A. obtectus* include *Mylabris obtectus* and *Bruchus obtectus,* while synonyms of *Z. subfasciatus* are *Z. pectoralis, Z. dorsopictus* and *Spermatophagus subfasciatus*. Both pests are widely distributed from Chile to the United States. Common names frequently used for bruchids in Latin America include gorgojo, gorgojo pintado, gorgojo común del fríjol, caruncho and gorgulho de feijao.

At least 28 other insects are reported to occur on stored beans but are of minor importance or migrate from nearby stored produce onto beans.

The life history of the two most important bean storage pests, *A. obtectus* and *Z. subfasciatus,* is basically similar and was studied in detail by Howe and Currie (51). The main difference is in oviposition behavior. *A. obtectus* females scatter eggs among stored seeds or infest beans in the field where they lay eggs in cracks or cuts of growing pods. The newly-hatched larvae of *A. obtectus* later penetrate the seed. In contrast, *Z. subfasciatus* eggs are firmly attached to the seed and after hatching, the young larvae bore through their eggshell and the seedcoat in one process (51).

Larvae of both species molt four times before pupating. During the last larval instar, the feeding and pupation cell becomes externally visible as a circular window in the seed where larvae feed on the lower testa surface. After pupation the adult may remain in the cell for several days before pushing out the window. It also has the ability to emerge by eating away the exit. Adults normally do not eat but may consume water or nectar. Oviposition starts rapidly after emergence as adults are short-lived (51).

The optimum conditions for rapid development of *A. obtectus* eggs are 70% RH and 30°C, when the insects spend 22-23 days inside the beans. Mortality during development occurs mainly when larvae penetrate the seed or when the exit hole is not large enough for adult emergence. Adults live 12 days at 30°C and 70% relative humidity. A female may lay an average of 63 eggs (51).

The optimum development period for *Z. subfasciatus*, including the egg stage, is about 25 days at 70% RH and 32.5°C. In this species, 7% of adults were unable to escape from the pupal cell (Fig. 40) and died. *Zabrotes subfasciatus* adults exhibit strong sexual dimorphism. The female usually weighs 1.5 times as much as the male. Adults live eight days at 30°C and 70% RH. A female may lay and average of 36 eggs (51).

Acanthoscelides obtectus (Fig. 41) is distributed throughout higher latitudes and altitudes, while *Zabrotes subfasciatus* (Fig. 42) is found predominantly in warmer areas (103). In studies by Giles in Nicaragua (Giles, personal communication), beans were infested inititally with *A. obtectus* (99.7%) and *Z. subfasciatus* (0.3%) at different elevations above sea level. After 16 weeks the ratio became 0: 100% at 56 m; 5: 95% at 450 m; and 27: 73% at 680 m. Average temperatures at these three elevations were 28.2°C, 25.2°C and 24.3°C, respectively. These data suggest that *A. obtectus* is a stronger competitor at lower temperatures.

No precise information was found in the literature concerning economic losses caused by insects in stored beans (Fig. 43). McGuire and Crandall (72) estimate that storage losses may reach 35% in Mexico, Central

Fig. 40- Pupal cells of *Zabrotes subfasciatus;* note the eggs firmly attached to the seed.

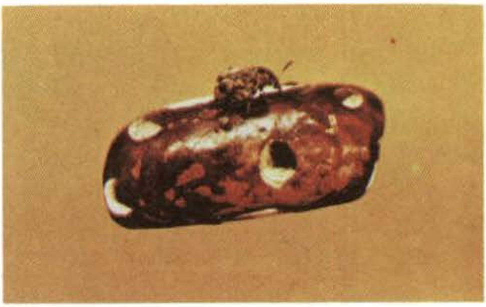


Fig. 41- Adult *Acanthoscelides obtectus.*

Fig. 42- Adults of *Zabrotes subfasciatus.*

Fig. 43- Beans destroyed by a serious attack of *Zabrotes subfasciatus.*

America and Panama, but they do not specify if losses are caused by insects or other factors. A marketing survey in the Recife area of Brazil revealed that the average storage and handling losses incurred during the marketing process amounted to 13% (107). A survey of farms in bean-growing areas and 30 warehouses in Colombia revealed that the average storage period is short and that only an estimated 7% loss occurred (103).

Farmers control weevils by applying ashes from fireplaces to beans stored for future planting. This method appeared to be effective (15) as a physical barrier to weevils. Storing beans in undamaged pods is a safe control measure against *Zabrotes subfasciatus* attack. Eggs deposited on the podwalls hatch and larvae penetrate the podwalls but die inside the pods without penetrating the seed. However, this method cannot be used to control *Acanthoscelides obtectus,* since this insect is able to attack beans in the pods. Labeyrie (53) showed that storing beans unshelled or delaying the harvest greatly enhanced *Acanthoscelides obtectus* attack. Another non-chemical method for controlling weevils is the use of black pepper. One gram of ground pepper per 385 g of beans reduced infestations of *A. obtectus* by 78% after four months storage when compared to untreated lots (55). Inert dusts, such as crystalline silica, bentonite and magnesium carbonate effectively kill *A. obtectus.* Apparently the fraction of fine particles determines the efficiency of control. Adult death rates of 50% in 12 hours by bentonite has been ascribed to water loss (13).

Vegetable oils, applied at the rate of 1 ml oil/kg seed, reduced progeny production on bean seed treated with cotton seed oil to five Bruchids, compared to 265 on non-treated samples. The treated seed retained its germination ability (17). Total control was obtained with 5 ml oil/kg seed. No adults emerged from material infested 75 days after treatment (104).

Chemical control of weevils is readily obtained with a variety of products. Pyrethrins are highly effective (70, 102). Pyrethrins with bases of marc gave long-lasting control and provided more acceptable seed appearance than Pyrethrins with talc as carrier (15). Synthetic Pyrethrins also gave excellent control. Most warehouses in Colombia used few products to control storage insects. In 33% of the warehouses, owners used aluminium phosphide, 40% used methyl bromide, 27% used carbon bisulfide and 13% used Pyrethrin. One warehouse owner confessed he used Aldrin to control bruchids (103).

Much of the *Phaseolus vulgaris* germplasm collection of CIAT has been tested for resistance to *Z. subfasciatus.* Several entries were rated inititally resistant but were susceptible when retested. Seed should show resistance during at least two seed generations before it can be considered resistant and useful for further studies. Varietal resistance to the bruchids also has been reported by Lefebre (56), Pabón *et al.* (84) and Ramalho *et al.* (94).

Other Pests

Mites

Spider Mites

Tetranychus desertorum Banks (Acarina: Tetranychidae).

Spider mites usually attack beans (Fig. 44) near physiological maturity and rarely affect yield. Common species are *T. desertorum* and *T. telarius*. *T. desertorum* has a wide host range as Nickel (83) observed 13 hosts in Paraguay. Common names frequently used for the red spider mite in Latin America include acaros, arañita roja and ácaro rajado.

Fig. 44- Leaf damage and webs produced by spider mites.

The biology of *T. desertorum* was studied by Nickel (83) who concluded that low temperatures limit geographical distribution of the pest. In laboratory studies on beans in Colombia, the incubation period lasted five days, the immature stages six days, and the female oviposited an average of four eggs per day during 15 days (85). This is a slightly slower development rate and also a lower oviposition rate than cited by Nickel.

The cultivars Oregón 58 R (J.G. Rodríguez, personal communication) and CRIA -.1-1, are resistant in Peru. Under CIAT greenhouse conditions, both were more resistant than ICA-Pijao and Diacol-Calima, but in the field Oregón 58 R was as susceptible as Diacol-Calima and ICA-Pijao. CRIA-1-1 exhibited an intermediate level of resistance. Biological control by several predator mites has been effective in detailed studies. However, chemical control is used mostly. Mites can become resistant to pesticides, thereby requiring the application of different combinations of chemicals. Gonzalez (35) recommends the use of uniform restricted planting dates and chemical control with Omethoate mixed with Oxydemetonmethyl or Tetradifon with Monocrotophos. Wilcox and Howland (121) recommend Phorate and Disulfoton as granular soil-applied insecticides for lima beans.

Tropical Mites

Polyphagotarsonemus latus (Banks) (Acarina: Tarsonemidae).

P. latus, sometimes called the tropical mite, can attack beans and cause post-flowering damage especially during humid and warm weather. The mite genus is synonymous with *Tarsonemus, Neotarsonemus* and *Hemitarsonemus.* It is a small pale green mite, difficult to see without magnification and little known on beans. Common names frequently used for the tropical spider mite in Latin America include acaro blanco, acaro branco and acaro tropical.

The mite is a bean pest in Brazil (18) and in the Cauca Valley of Colombia. It also has been observed in Peru and Central America. Many other hosts beside beans are known and include potato (22), tomato, *Centrosema* spp., *Dolichos* spp. (20), green pepper, dahlia and cotton (45). The mite also attacks several common weeds in bean fields. Measurements on individual plants have revealed 56% yield loss in beans grown at CIAT (15).

The tropical mite has a short life-cycle which is composed of the egg, larva, pseudopupa (developmental stages) and adult stage. The developmental stages last one to three, two, and two days respectively at 27°C (27). Under laboratory conditions of 22° - 28°C at CIAT (105), the duration of these periods was two, one, and one day, respectively. Males lived for 12 days, while females lived 15 days and laid an average of 48 eggs.

Symptoms of mite damage become evident as leaf edges roll upwards and have a shiny appearance (Fig. 45). Depending on the cultivar, the lower leaf surface may turn purple. Young leaves do not develop normally and remain stunted, often turning yellow to gold (Fig. 46). The pods can be attacked and become covered with a brown wound tissue (Fig. 47) which may resemble sunscald damage. Some cultivars show a downward curling of leaf edges and a darkening of the leafblade. Symptoms are commonly confused with those induced by virus or mineral deficiencies.

Endosulfan, Monocrotophos, Carbaryl, Dicofol, Triazophos and Omethoate provide good chemical control at CIAT (105). Costa (19)

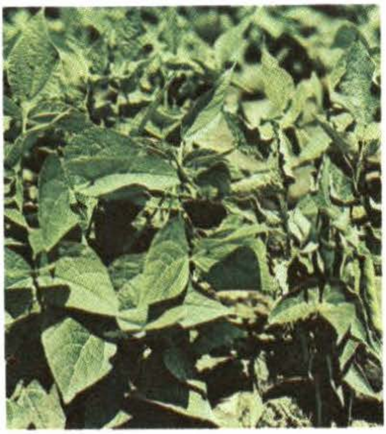


Fig. 46- (above) Discoloration of lower leaf surface due to tropical mite.

Fig. 45- (left) Leaf rolling symptoms caused by tropical mite damage.

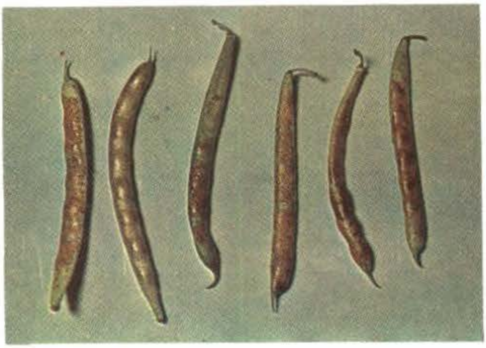


Fig. 47- Discoloration of bean pods due to tropical mite.

Fig. 48- Adult slug on bean plant with pod and leaf-feeding damage.

recommends Carbophenothion, Chlorobenzilate, Chlorfensulphide and Endosulfan for control on cotton. Mite populations apparently are stimulated by Dimethoate (47).

Slugs

Slugs (Fig. 48), like mites, do not belong to the class of insects, however, occasionally are serious bean pests in El Salvador and Honduras. The reported species belong to the family Limacidae, and include *Vaginulus plebeius* Fisher, *Limax maximus* L. and *Deroceras agreste* L. (49, 64). Common names frequently used for slugs in Latin America are babosas and lesmas.

Although hermaphroditic, after copulation females lay up to 800 eggs in egg masses under plant debris or in soil cracks. At 27°C they hatch in 24 days and reach sexual maturity three or four months later. Slugs are nocturnal but may be active during wet, cloudy days. Young slug damage is apparent when whole leaves, with the exception of the veins, are consumed

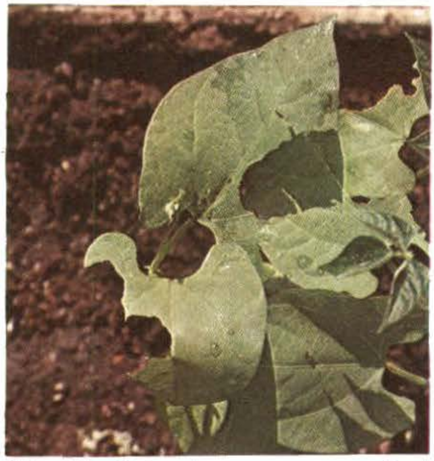


Fig. 49- Leaf damage due to slug feeding.

(Fig. 49). Older slugs consume entire leaves. Entire seedlings also may be consumed, and pod damage may occur. Most damage occurs along borders of fields and progresses inwards, especially if vegetation and debris provide ample protection for the slugs during the day.

Control is best achieved by cleaning fields and borders of weeds and plant debris. Curative control is obtained with baits, such as Methaldehyde or Carbaryl applied in bands along borders or within affected areas in the late afternoon. Some formulations are (per ha): Methaldehyde 99% (65 g) mixed with wheatbran (25 kg) and molasses (20 l). Carbaryl 80% (0.5 kg) or Thrichlorfon (0.5 kg) may be used to replace Methaldehyde (64).

Future of Insect Control in Latin America

Cultivars are available which possess genetic resistance to insect pests such as *Empoasca kraemeri, Apion godmani, Epilachna varivestis,* and *Epinotia opposita.* The main objective in bean entomology research should be to incorporate resistance to key insect pests into commercially acceptable cultivars which already posses resistance to plant diseases such as bean common mosaic virus and rust.

Development of varietal resistance will take time, during which most national programs are improving current chemical control recommendations. Recent studies with systemic granular insecticides such as Carbofuran or Phorate have reduced bean golden mosaic virus incidence greatly and may preserve natural biological control. Several bean programs still recommend application of chlorinated hydrocarbons to control insect pests.

Future emphasis must be placed on development of a pest management system within which biological, cultural and other control strategies are an integral part. However, the short growing season of beans and fallow periods may reduce the effectiveness of biological control in these systems. The increasing use of resistant cultivars should reduce the need for pesticides and assure the survival of agents contributing to biological control. It may be desirable to locate and release more efficient natural enemies. However, national programs may be restricted by lack of funds and trained personnel. Biological control by other agents, such as parasitic fungi or bacteria, also must be investigated further.

Cultural practices should play an important role in a pest management system. Shifting of planting dates may be a powerful tool in controlling insects. However, it has limited application where rainfall distribution primarily governs planting dates. *Empoasca kraemeri* control is favored by planting at the beginning of the rainy season when leafhopper populations are low. *Hylemya* spp. control is favored by a late planting date, and a preplant plowing may also be useful. However, the biology and ecology of most insect pests has not been studied sufficiently to allow valid recommendations.

As discussed before, the distribution of principal bean insects varies greatly within Latin America. Proper quarantine measures also should continue to be enforced to limit pest distribution.

The most important aspect of crop pest management will be elimination of unnecessary pesticidal applications in a practical and economical manner. Accurate knowledge must be obtained between the relationship of insect pest populations and yield reductions. Most entomologists involved with bean research expect that a certain amount of feeding damage can be sustained by the plant before economically significant yield reduction occurs. Leafhopper research indicates that the first insect present on a plant causes more damage than those which follow (16). This indicates that the decision to spray is not only based upon expected yield loss, but also upon the cost of insecticidal spray and the consequences of this spray to later pest development, such as lepidopterous insects and their biological enemies. The curve of population level versus *Empoasca kraemeri* damage is different from that of foliage feeders where part of the foliage can be removed without adversely affecting yield.

Associated cropping is a system in which an estimated 80% of the beans in Latin America are grown. This system demands more attention. It is possible that abandoning this system may reduce the stability of the ecosystem and increase specific insect pest populations and their importance.

Finally, excellent work has been accomplished by Latin American entomologists. However, lack of funds often prohibits publication of this work, so others cannot profit from their knowledge and experience. The vacuum thus created has hindered more rapid progress in bean entomological research to reduce bean yield losses due to insects in Latin America.

Table 1. Major insect pests of beans in Latin America.

SEEDLING-ATTACKING INSECTS	
Seed Corn Maggot	*Hylemya* spp.
Cutworm	*Spodoptera frugiperda*
Whitegrub	
Cricket	
Lesser Corn Stalk Borer	*Elasmopalpus lignosellus*
LEAF-FEEDING INSECTS	
Chrysomelids	*Diabrotica balteata*
	Cerotoma spp.
Lepidoptera-Saltmarsh Caterpillar	*Estigmene acrea*
-Bean Leafroller	*Urbanus proteus*
	Hedylepta indicata
Mexican Bean Beetle	*Epilachna varivestis*
SUCKING INSECTS	
Leafhopper	*Empoasca kraemeri*
White Fly	*Bemisia tabaci*
Aphids	*Aphis* spp.
Thrips	*Caliothrips braziliensis*
POD-ATTACKING INSECTS	
Bean Pod Weevil	*Apion godmani*
Pod Borers	*Epinotia opposita*
	Laspeyresia leguminis
	Maruca testulalis
	Heliothis spp.
STORAGE INSECTS	
Bruchids	*Zabrotes subfasciatus*
	Acanthoscelides obtectus
OTHER PESTS	
Mites - Spider Mites	*Tetranychus* spp.
-Tropical Mites	*Polyphagotarsonemus latus*
Slugs	*Vaginulus plebeius*

Table 2. Most important insect pests in 12 Latin American countries (43)*.

Pest damage group	Principal species	Number of countries in which insect is important
Piercing Insects	*Empoasca* spp.	12
Leaf-feeding Insects	*Diabrotica* spp.	10
(not Lepidoptera)	*Epilachna* spp.	10
Cutworms, Crickets	—	8
Pod-attacking Insects	*Apion godmani*	5
Stored Grain Insects	—	5

Brazil, Colombia, Costa Rica, El Salvador, Guatemala, Haiti, Honduras, Nicaragua, Panama, Paraguay, Peru and Dominican Republic.

Table 3. Relative importance* of bean insects in Central America (6).

Country	Leafhoppers	Chrysomelids	Bean pod weevil	Whitefly	Mexican bean beetle
Costa Rica	4	4	1	2	1
Nicaragua	3	3	1	3	3
El Salvador	4	3	3	2	1
Honduras	4	3	4	3	1
Guatemala	4	2	3	2	4

* Relative importance measured on a 0-4 scale: 0 = insects absent; 4 = insects very numerous.

Table 4. Average percent yield loss (highest yielding insecticidal treatment compared with untreated plots) from 16 insecticidal trials reported in bean literature.

Area	Number of experiments	Principal insect involved	Average % yield loss
Mexico, El Salvador	5	*Apion godmani*	54.2
Mexico	3	*Empoasca kraemeri*	64.0
Mexico	2	*Epilachna varivestis*	55.0
El Salvador, Mexico, Puerto Rico	6	Unspecified	30.5
Total	16	Weighted average	47.25

Literature Cited

1. ALAE. 1968. Asociación Latinoamericana de Entomología. Catálogo de insectos de importancia económica en Colombia. Public. No. 1, 156 p.

2. Alomia, B.E. 1974. El *Epinotia opposita* Heinr. (Lepidoptera: Olethreutidae), plaga del fríjol en Antioquia. ICA, Medellín, Colombia, 5 p.

3. Alonso, F. 1975. Estudios en *Phaseolus vulgaris* L. sobre el control de la mosca blanca, *Bemisia tabaci* (Genn.) en la zona suroriental de Guatemala. Paper presented at Workshop on Bean Plant Protection, CIAT, 18 p.

4. Augustine, M.G., F.W. Fisk, R.W. Davidson, J.B. LaPidus and R.W. Cleary. 1964. Host-plant selection by the Mexican bean beetle *Epilachna varivestis*. Ann. Entomol. Soc. Amer. 57: 127-134.

5. Beyer, A.H. 1922. The bean-leafhopper and hopperburn with methods of control. Florida Agr. Exp. Sta. Bull. No. 164, pp. 61-88.

6. Bonnefil, L. 1965. Las plagas del fríjol en Centro América y su combate. *In*. XI Reunión del PCCMCA, Panama, March 17-19, pp. 95-103.

7. Boonekamp, G. 1978. Studies on damage of *Diabrotica balteata* LeConte and *Cerotoma facialis* Erichson (Coleoptera: Chrysomelidae) to common beans (*Phaseolus vulgaris* L.). Centro Internacional de Agricultura Tropical, CIAT, 56 p.

8. Broadley, R.H. 1977. The bean pod borer in North Queensland. Queensland Agr. J. 103: 274-278.

9. Cadena, D. and J.A. Sifuentes. 1969. Prueba comparativa de la efectividad de 4 insecticidas para combatir la conchuela del fríjol *(Epilachna varivestis)* bajo condiciones de campo. Agr. Tec. en México 2: 440-444.

10. Campbell, W.W. and C.H. Brett. 1966. Varietal resistance of beans to the Mexican bean beetle. J. Econ. Entomol. 59: 899-902.

11. Campos, J. 1972. Insecticidas impregnados a la semilla del maíz para el control de *Elasmopalpus lignosellus* (Zeller) (Lepidoptera: Pyralidae). Rev. Peruana de Entomol. 15: 348-351.

12. Chalfant, R.B. 1965. Resistance of bush bean varieties to the potato leafhopper and relationship between resistance and chemical control. J. Econ. Entomol. 58: 681-682.

13. Chiu, S.F. 1929. Toxicity studies of so-called "inert" materials with the bean weevil *Acanthoscelides obtectus* (Say). J. Econ. Entomol. 32: 240-248.

14. CIAT. 1974. Bean Production Systems. *In*, Ann. Rept. 1973. Centro Internacional de Agricultura Tropical, Cali, Colombia, pp. 170-175.

15. CIAT. 1975. Bean Production Systems. *In*, Ann. Rept. 1974. Centro Internacional de Agricultura Tropical, Cali, Colombia, pp. 125-129.

16. CIAT. 1976. Bean Production Systems. *In,* Ann. Rept. 1975. Centro Internacional de Agricultura Tropical, Cali, Colombia, pp. 129-136.

17. CIAT. 1977. Bean Production Systems. *In,* Ann. Rept. 1976. Centro Internacional de Agricultura Tropical, Cali, Colombia, pp. 15-22.

18. Costa, C.L. and C.J. Rossetto. 1972. Investigacoes sobre pragas de feijoeiro no Brasil. *In,* Anais do I Simposio Brasileiro de Feijao. Campinas, 22-29 August, 1971, 2a. Vol., Impr. Univ. Vicosa, M.G., Brazil.

19. Costa, D.S. 1970. Acaros inimigos invisiveis do algodoeiro. Divulg. Agron. 29: 6-9.

20. Cromroy, H.L. 1958. A preliminary survey of the plant mites of Puerto Rico. J. Agr. Univ. Puerto Rico 42: 39-144.

21. De la Paz, S., R. Reyna and A. Martínez. 1979. El rendimiento de fríjol en función del grado de daño de la conchuela (*Epilachna varivestis* Muls.). In press.

22. Doreste, E. 1968. Primera lista de ácaros de importancia agrícola en Venezuela. Agron. Trop. (Venezuela) 18: 452.

23. Dupree, M. 1965. Observations on the life history of the lesser cornstalk borer. J. Econ. Entomol. 58: 1156-1157.

24. Eckenrode, C.J., N.L. Gauthier, D. Danielson and R. Webb. 1973. Seedcorn maggot: Seed treatments and granule furrow applications for protecting beans and sweet corn. J. Econ. Entomol. 66: 1191-1194.

25. Elmore, J.C. 1949. Hibernation and host-plant studies of the Mexican bean beetle in California. J. Econ. Entomol. 42: 464-466.

26. Enkerling, D. 1951. El picudo del ejote, *Apion godmani* Wagn., su importancia económica y experimentos para su control en el estado de Michoacan, México. Sec. de Agr. y Ganadería, Folleto Misc. 4: 126-130.

27. Flechtman, C.H.W. 1972. Acaros de importancia agrícola. Sao Paulo Novel, 150 p.

28. Fluiter, H.J. de and G.W. Ankersmit. 1948. Gegevens betreffende de aantasting van bonen (*Phaseolus vulgaris* L.) door de zwarte bonenluis (*Aphis (Doralis) fabae* Scop). Tijdschrift over Pflantenziekten 54: 1-13.

29. Gámez, R. 1972. Los virus del fríjol en Centro América. II. Algunas propiedades y transmisión por crisomélidos del virus del mosaico rugoso del fríjol. Turrialba 22: 249-257.

30. García, C. 1971. Control del pegador de hojas y de la mosca de los brotes del pallar. (Investigación de control químico). Ministerio de Agricultura y Pesquería Boletín de Menestras 19, 5 p.

31. García, C. and C. Sosa. 1973. Evaluación de la resistencia de fríjol hacia la conchuela *Epilachna varivestis* Muls. (Coleoptera: Coccinellidae). Agrociencia Serie D, 10: 3-13.

32. García, F. 1975. Plagas de la soya. *In,* El cultivo de la soya en Colombia. Inst. Colombiano Agrop. (ICA), Compendio 6, 56 p.

33. Gates, D. 1945. Bean insect control. *In,* Nebraska Agr. Exp. Sta. Ann. Rept., pp. 58-61.

34. Gómez, L.A. and A. v. Schoonhoven. 1977. Oviposición del *Empoasca kraemeri* en fríjol y evaluación del parasitismo por *Anagrus* sp. Rev. Colombiana de Entomol. 3: 29-38.

35. González, P.M. 1969. Resultados del control químico de la arañita roja (*Tetranychus* sp.) en fríjol en el Valle de Camara, Arequipa. Rev. Peruana de Entomol. 12: 58-70.

36. Gould, H.J. and J.G. Mayor. 1975. Alternative seed treatments to dieldrin for the control of bean seed fly (*Delia* spp.). Plant Path. 24: 245-246.

37. Greene, G.L. 1971. Economic damage levels of bean leaf roller populations on snap beans. J. Econ. Entomol. 64: 673-674.

38. Greene, G.L. 1971. Instar distributions, natural populations, and biology of the bean leaf roller. Florida Entomol. 54: 213-219.

39. Greene, G.L. and D.R. Minnick. 1967. Snap bean yields following simulated insect defoliation. Proc. Florida State Hort. Soc. 80: 132-134.

40. Guevara, J. 1957. El desarrollo y uso de variedades de fríjol resistentes a ciertas plagas de las leguminosas. Sobretiro de la Revista Chapingo, Nos. 62-66, 61 p.

41. Guevara, J. 1962. El combate del picudo del ejote mediante la combinación de variedades resistentes e insecticidas. Agr. Tec. en México 2: 17-19.

42. Guevara, J. 1969. Resistencia a insectos. *In,* O. Brauer, Fitogenética Aplicada. Edit. Lenusa - Wiley S.A., Mex., 518 p.

43. Gutiérrez, U.M., M. Infante and A. Pinchinat. 1975. Situación del cultivo de fríjol en América Latina. Centro Internacional de Agricultura Tropical, CIAT Serie ES-19, 33 p.

44. Hagen, A.F. 1974. Mexican bean beetle control with systemic insecticides on dry beans in western Nebraska. J. Econ. Entomol. 67: 137.

45. Hambleton, E.J. 1938. A ocorrencia do acaro tropical *Tarsonemus latus* Banks (Acar. Tarsonemidae) causador da rasgadura das folhas nos algodoais de S. Paulo. Arq. Inst. Biol. 9: 201-209.

46. Harris, C.R., H.J. Svec and J.A. Begg. 1966. Mass rearing of root maggots under controlled environmental conditions: Seedcorn maggot, *Hylemya cilicrura;* bean seed fly, *H. liturata; Euxesta notata;* and *Chaetopsis* sp. J. Econ. Entomol. 59: 407-410.

47. Harris, K.M. 1969. Population increase of *Steneotarsonemus pallidus* (Banks) following spray applications of dimethoate. Plant Path. 18: 113-115.

48. Harris, V. 1975. Zur innerartlichen Variabilitaet,Wirtspflanzen Praeferentz und Schadendeutung von Blattkaefern der U.F. Galerucinae (Col., Chrysomelidae) in Feld Culturen des Cauca Flusstals/Columbien. Zeitschr. Fuer. Angew. Zool. 62: 491-497.

49. Hawley, I.M. 1922. Insects and other animal pests injurious to field beans in New York. Cornell Univ. Agr. Exp. Sta., Ithaca, N.Y., Mem. 55: 977-999.

50. Hertveldt, L. and G. Vulsteke. 1972. Biology and control of the bean fly, *Hylemya cilicrura* Rond. Mededelingen van de Faculteit Landbouwwethenschappen, Ryksuniversiteit, Gent. 37: 139-153.

51. Howe, R.W. and J.E. Currie. 1964. Some laboratory observations on the rates of development, mortality and oviposition of several species of Bruchidae breeding in stored pulses. Bull. Entomol. Res. 55: 437-477.

52. Kappor, K.N., J.P. Gujrati and G.A. Gangrade. 1972. Bionomics of *Lamprosema indicata* Fabricius, a pest of soybeans in Madhya Pradesh. Indian J. Entomol. 34: 102-105.

53. Labeyrie, V. 1957. Influence des technique de recoltes des haricots secs l'intensité des attaques de la Bruche (*Acanthoscelides obtectus* Say). Conte Rendu Acad. Agr. 43: 138-140.

54. LaPidus, J.B., R.W. Cleary, R.H. Davidson, F.W. Fisk and M.G. Augustine. 1963. Chemical factors influencing host selection by the Mexican bean beetle *Epilachna varivestis* Muls. J. Agr. and Food Chem. 11: 462-463.

55. Lathrop, F.H. and L.G. Keirstead. 1946. Black pepper to control the bean weevil. J. Econ. Entomol. 39: 534.

56. Lefebre, P.C. 1950. *Bruchus obtectus* Say ou bruche des haricots (*Phaseolus vulgaris* L.). Public. de Inst. Natl. Pour L'Etude Agron. du Congo Belge (INEAC) 48: 1-65.

57. Lenis, G. and D. Arias. 1976. Contribución al conocimiento de *Hedylepta indicata* Fabricius (Lepidoptera: Pyralidae) y de sus más frecuentes enemigos naturales. Tesis, Univ. Nac. de Agron., Palmira, Colombia, 46 p.

58. Leonard, M.D. 1931. A preliminary report on the lima bean pod-borer and other legume pod-borers in Puerto Rico. J. Econ. Entomol. 24: 466-473.

59. Leuck, D.B. 1966. Biology of the lesser cornstalk borer in south Georgia. J. Econ. Entomol. 59: 797-801.

60. Leuck, D.B. and M. Dupree. 1965. Parasites of the lesser corn stalk borer. J. Econ. Entomol. 58: 779-780.

61. Mancía, J.E. 1973. Evaluación de variedades de fríjol tolerantes al picudo de la vaina *Apion godmani* Wagn. SIADES 2: 15-20.

62. Mancía, J.E. 1973. La biología del picudo de la vaina del fríjol *Apion godmani* Wagn., y su distribución en El Salvador. SIADES 2: 12-29.

63. Mancía, J.E. 1973. Evaluación de insecticidas sistémicos granulados para el combate del picudo de la vaina del fríjol *Apion godmani* Wagn. *In,* XIX Reunión Anual PCCMCA, San José, Costa Rica, 13 p.

64. Mancía, J.E. 1973. Biología y control de la babosa del fríjol *Vaginulus plebeius* Fisher en El Salvador. Ministerio de Agr. y Ganad. CENTA, Circular No. 96, 12 p.

65. Mancía, J.E. and M.R. Cortez. 1975. Lista de insectos clasificados, encontrados en el cultivo del fríjol *Phaseolus vulgaris* L. SIADES 4: 120-136.

66. Mancía, J.E. and M. Román C. 1973. Biología de la conchuela del fríjol común *Epilachna varivestis* Muls. *In,* XIX Reunión Anual del PCCMCA, San José, Costa Rica, 5-8 March, 10 p.

67. Mancía, J.E., M.R. Cortez and O. Gracias. 1973. Efectividad de varios insecticidas en el combate del picudo de la vaina del fríjol común, *Apion godmani* Wagn. 1971-1972, El Salvador. SIADES 2: 2-14.

68. Mancía, J.E., A. Diaz and O. Gracias. 1973. Utilización de insecticidas sistémicos granulados en el control de mosca blanca *Bemisia tabaci* Genn. e infección virosa en fríjol. *In,* XIX Reunión Anual del PCCMCA, San José, Costa Rica, 5-8 March, 9 p.

69. Mancía, J.E., O. Gracias and M. Cortes. 1974. Determinación de la mejor época de control del picudo de la vaina del fríjol común *Apion godmani* Wagn. SIADES 31: 59-66.

70. McFarlane, J.A. 1970. Control of the bean bruchid *Acanthoscelides obtectus* (Say) by synergised pyrethrin powders. Pyrethrin Post. 10: 34-40.

71. McFarlane, J.S. and G.M. Rieman. 1943. Leafhopper resistance among the bean varieties. J. Econ. Entomol. 36: 639.

72. McGuire, J.U. and B.S. Crandall. 1967. Survey of insect pests and plant diseases of selected food crops of Mexico, Central America and Panama. Int. Agr. Dev. Serv., Agr. Res. Serv., U.S.D.A., AID, 157 p.

73. McKelvey, J.J., J. Guevara and A. Cortez. 1947. *Apion* pod weevil: A pest of beans in Mexico. J. Econ. Entomol. 40: 476-479.

74. McKelvey, J.J., A.C. Smith, J. Guevara and A. Cortes. 1951. Biología y control de los picudos del género *Apion* que atacan al fríjol en México. Secretaría de Agr. y Ganad., Folleto Tec. 8: 7-42.

75. McKinney, K.B. 1938. Physical characteristics on the foliage of beans and tomatoes that tend to control some small insect pests. J. Econ. Entomol. 31: 630-631.

76. McLeod, D.G.R. 1965. Are *Hylemya cilicrura* and *H. liturata* two separate species? Proc. Entomol. Soc. Ontario 95: 140-142.

77. Medina, R. and L. Guerra. 1973. Evaluación del comportamiento genético de fríjol infestado en forma natural con chicharrita, (*Empoasca fabae* Harris), picudo, *Apion godmani* (Wagner) y conchuela del fríjol *Epilachna varivestis* en Calera, Zac. CIANE, 13 p.

78. Metcalf, G.L. and W.P. Flint. 1972. Insectos destructivos e insectos útiles. Sus costumbres y su control. Co. Edit. Cont. S.A., Mexico, 1208 p.

79. Miller, L.A. and R.J. McClanahan. 1960. Life history of the seed-corn maggot, *Hylemya cilicrura* (Rond) and of *H. liturata* (Mg.) (Diptera: Anthomyiidae) in South-western Ontario. Canadian Entomol. 92: 210-221.

80. Miranda, C. 1967. Fechas de siembra e incidencia de *Empoasca* spp. en fríjol. *In*, XIII Reunión PCCMCA, San José, Costa Rica, Feb. 28-March 4.

81. Miranda, S. 1971. Efecto de las malezas, plagas y fertilizantes en la producción de fríjol. Agr. Tec. en México 3: 61-66.

82. Nayar, J.K. and G. Fraenkel. 1963. The chemical basis of the host selection in the Mexican bean beetle, *Epilachna varivestis* (Coleoptera: Coccinellidae). Ann. Entomol. Soc. Amer. 56: 174-178.

83. Nickel, J.L. 1960. Temperature and humidity relationships of *Tetranychus desertorum* Banks with special reference to distribution. Hilgardia 30: 41-100.

84. Pabón, I., C. Aguirre and J.A. Reyes. 1976. Resistencia de diez y siete variedades comerciales de fríjol en almacenamiento, al ataque del gorgojo pintado de los granos (*Zabrotes subfasciatus* Boh.). Acta Agron. 26: 39-47.

85. Piedrahita, J. 1974. Biología de *Tetranychus desertorum* Banks (Acarina; Tetranychidae) y pruebas de resistencia de 7 variedades de fríjol *(P. vulgaris)*, a su ataque. Tesis, Univ. Nac. Fac. Agron., Palmira, Colombia, 40 p.

86. Pillemer, E.A. and W.M. Tingey. 1976. Hooked trichomes: a physical plant barrier to a major agricultural pest. Science 193: 482-484.

87. Pinstrup-Andersen, P., N. de Londoño and M. Infante. 1976. A suggested procedure for estimating yield and production losses in crops, with an empirical application to bean in Cauca Valley, Colombia. PANS 22: 359-365.

88. Pitre, H.N. and E.J. Kantack. 1962. Biology of the banded cucumber beetle, *Diabrotica balteata*, in Louisiana. J. Econ. Entomol. 55: 904-906.

89. Posada, L. and F. García. 1976. Lista de predatores, parásitos y patógenos de insectos registrados en Colombia. Min. de Agr. ICA Boletin Tec. 41, 90 p.

90. Posada, L., I.Z. de Polonia, I.S. de Arévalo, A. Saldarriaga, F. García and R. Cárdenas. 1970. Lista de insectos dañinos y otras plagas en Colombia. Min. de Agr., ICA Public. Misc. 17, 202 p.

91. Pulido, J.I. and C. López. 1973. Biología y algunas plantas hospedantes del cucarroncito de las hojas *Diabrotica balteata* LeConte (Coleoptera: Chrysomelidae). Tesis, Fac. Agr. Univ. Nac., Palmira, Colombia, 50 p.

92. Quaintance, A.L. 1898. Three injurious insects: bean leafroller, corn delphax, Canna leafroller. Florida Agr. Exp. Sta. Bull. 45: 53-74.

93. Raina, A.K., P.S. Benepal and A.Q. Sheikh. 1978. Evaluation of bean varieties for resistance to Mexican bean beetle. J. Econ. Entomol. 71: 313-314.

94. Ramalho, M.A.P., W. Botelhoe and L.O. Salgado. 1977. Comportamento de algumas variedades de feijao (*Phaseolus vulgaris* L.) quanto a suscetibilidade ao caruncho *Acanthoscelides obtectus* (Say). Anais 4° Congresso da SEB 6: 238-242.

95. Ramírez, M., E. Casas and A. Rubio. 1959. Susceptibilidad de algunas variedades de fríjol al picudo del ejote en la Mesa Central. Agr. Tec. en México 7: 6-38.

96. Rodas, H.R. 1973. Porcentaje de parasitismo, morfología, longevidad y posibilidad de cría de algunos dípteros parasitos de larvas de *Estigmene acrea columbiana* (Rothschild) (Lepidoptera: Arctiidae) en el Valle del Cauca. Tesis, Univ. Nac. Agron., Palmira, Colombia, 47 p.

97. Ross, H.H. and T.E. Moore. 1957. New species in the *Empoasca fabae* complex (Homoptera: Cicadellidae). Ann. Entomol. Soc. Amer. 50: 118-121.

98. Rossetto, C.J., L. de Santis, O. Paradela and A.S. Pompeu. 1974. Espécies de tripses coletados em culturas de feijoeiro. Bragantia 33: 9-14.

99. Ruppel, R.F. and D.M. DeLong. 1956. *Empoasca* (Homoptera: Cicadellidae) from highland crops of Colombia. Bull. Brooklyn Entomol. Soc. 51: 85-92.

100. Ruppel, R.F. and E. Idrobo. 1962. Lista preliminar de insectos y otros animales que dañan fríjoles en América. Agr. Trop. 18: 651-679.

101. Russell, L.M. 1975. Whiteflies on beans in the western hemisphere. Paper presented at Workshop on Bean Plant Protection, CIAT, Dec. 1-3, 21 p.

102. Salas, L. and R.F. Ruppel. 1959. Efectividad de insecticidas aplicados en polvo para controlar las principales plagas del fríjol y del maíz almacenados en Colombia. Agr. Trop. (Colombia) 15: 93-108.

103. Schoonhoven, A. van. 1976. Pests of stored beans and their economic importance in Latin America. Paper presented at: 15 th. Int. Congress, Entomol. Symp. Tropical Stored Prod. Entomol. Aug. 19-27, Washington D.C., 26 p.

104. Schoonhoven, A. van. 1978. Use of vegetable oils to protect stored beans from bruchid attack. J. Econ. Entomol. 71: 254-256.

105. Schoonhoven, A. van., J. Piedrahita, R. Valderrama and G. Gálvez. 1978. Biología, daño y control del ácaro tropical *Polyphagotarsonemus latus* (Banks) (Acarina: Tarsonemidae) en fríjol. Turrialba 28: 77-80.

106. Scott, L.B. 1940. The bean pod borers in Puerto Rico. J. Agr. Univ. Puerto Rico 24: 35-47.

107. Slater, C.C., M. Ruley, V. Farace, K. Harrison, F. Neves, A. Bogatay, M. Dortoroff, D. Larson, R. Nason and T. Welb. 1969. Market process in Recife area of Northeast Brazil. Rept. 2, Latin America Studies Center, Michigan State Univ.

108. Smiley, R.L. 1974. A new species of *Coccipolipus* parasitic on the Mexican bean beetle, (Acarina: Podapolipidae). Washington Acad. Sci. 64: 298-302.

109. Stevens, L.M., A.L. Steinhauer and T.C. Elden. 1975. Laboratory rearing of the Mexican bean beetle and the parasite *Pediobius foveolatus*, with emphasis on parasite longevity and host-parasite ratios. Environ. Entomol. 4: 953-957.

110. Stevenson, W.A., W. Kaufman and L.W. Sheets. 1957. The saltmarsh caterpillar and its control in Arizona. J. Econ. Entomol. 50: 279-280.

111. Stone, M.W. 1965. Biology and control of the lima bean pod borer in Southern California. U.S.D.A. Tech. Bull. 1321, 46 p.

112. Taylor, T.A. 1976. *Maruca testulalis* (Geyer) (Lepidoptera: Pyralidae), an important pest of tropical grain legumes. International Symposium on Pests of Grain Legumes, IITA, Ibadan, Nigeria, 21 p.

113. Thomas, F.L. 1924. Life history and control of the Mexican bean beetle. Alabama Agr. Exp. Sta. Bull. No. 221, 99 p.

114. Tissot, A.N. 1932. Studies on the bean Jassid. *In,* Florida Agr. Sta. Ann. Rept., pp. 73-74.

115. Torres, N. 1968. Un control químico de *Epinotia* sp. en fríjol. Rev. Peruana de Entomol. 11: 77-79.

116. Turner, N. 1932. The Mexican bean beetle in Connecticut. J. Econ. Entomol. 25: 617-620.

117. Turner, N. 1935. Effect of Mexican bean beetle injury on crop yield. J. Econ. Entomol. 28: 147-149.

118. Turnipseed, S.G. and M. Kogan. 1976. Soybean entomology. Ann. Rev. Entomol. 21: 247-282.

119. Van Dam, W. and G. Wilde. 1977. Biology of the bean leafroller *Urbanus proteus* (Lepidoptera: Hesperiidae). J. Kansas Entom. Soc. 50: 157-160.

120. Vea, E.V. and C.J. Eckenrode. 1976. Resistance to seed-corn maggot in snap bean. Environ. Entomol. 5: 735-737.

121. Wilcox, J. and A.F. Howland. 1960. Control of the two-spotted spidermite on beans with systemic insecticides applied in the soil. J. Econ. Entomol. 53: 224-227.

122. Wilde, G. and A. van Schoonhoven. 1976. Mechanism of resistance to *Empoasca kraemeri* in *Phaseolus vulgaris*. Environ. Entomol. 5: 251-255.

123. Wilde, G., A. van Schoonhoven and L. Gómez Laverde. 1976. The biology of *Empoasca kraemeri* on *Phaseolus vulgaris*. Ann. Entomol. Soc. Amer. 69: 442-444.

124. Wille, J.E. 1943. Entomología Agrícola del Perú. Min. de Agr. Lima, Peru, 466 p.

125. Wolfenbarger, D. and J.P. Sleesman. 1961. Plant characteristics of *Phaseolus vulgaris* associated with potato leafhopper nymphal infestation. J. Econ. Entomol. 54: 705-707.

126. Wolfenbarger, D. and J.P. Sleesman. 1961. Resistance in common bean lines to the potato leafhopper. J. Econ. Entomol. 54: 846-849.

127. Wolfenbarger, D. and J.P. Sleesman. 1961. Resistance to the Mexican bean beetle in several bean genera and species. J. Econ. Entomol. 54: 1018-1022.

128. Wolfenbarger, D. and J.P. Sleesman. 1961. Resistance to the potato leafhopper in lima bean lines, interspecific *Phaseolus* crosses, *Phaseolus* spp., the Cowpea and the Bonavist bean. J. Econ. Entomol. 54: 1077-1079.

129. Young, W.R. 1960. Banded cucumber beetle. Biological and ecological studies. *In,* Ann. Rept. Rockefeller Found., Agr. Sciences 1959-1960, pp. 73-74.

130. Young, W.R. and D. Candia. 1963. Biología y control de la "doradilla" en el campo Cotaxtla, Ver. Agr. Tec. en México 2: 33-38.

131. Young, W.R. and J.A. Sifuentes. 1959. Biological and control studies on *Estigmene acrea* (Drury), a pest of corn in the Yaqui Valley, Sonora, Mex. J. Econ. Entomol. 52: 1109-1111.

132. Yoshii, K. 1978. Evaluación de variedades del fríjol y piloy por resistencia al picudo de vainas. Resultados de 1977. Programa de fríjol ICTA/Guatemala, Informe mensual, 8 p.

133. Zaumeyer, W.J. and H.R. Thomas. 1957. A monographic study of bean diseases and methods for their control. U.S.D.A. Agr. Tech. Bull. No. 868, 255 p.