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Insects associated with beans in Latin America

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Introduction

Beans (Phaseolus vulgaris L) form an important part of the protein diet of the Latin American people Aproximately 3 86 million tons of beans are produced per year which is about 347 of the world s total production (avg 1968 1972 period) Nearly 607 of the beans in Latin America are grown in Brazil (Infante et al 1974)

Pests like in any other crop take their toll in bean production before and after harvest Attempts have continually been made to reduce these losses Overreliance on pesticides in bean production has been less than on some other crops Since a large part of the beans in Latin America are produced by farmers with small holdings and with less economic strength it makes them less prone to attack by the pesticides salesman Beans are often grown in association with other corps This may stabilize insect populations While such factors favor the development of an integrated control method the short growing season of beans causes rapid crop turn over and does not favor a stabile ecosystem helpful in pest management practices

In this paper we want to review the pertinent literature on bean pests in Latin America as well as some highlights of our own research program at CIAT We will emphasize bean pest ecology aspects and especial ly non chemical control methods No information on many of these pests was found in the Latin American lieterature and some information was col lected from other sources or from pests on other crops Little attention is given to bean insect problems in Brasil as this is covered elsewhere during this symposium

Economic threshold populations

An important aspect of pest management as in any crop is the insect damage level that can be economically tolerated Creene and Minnick (1967) obtained a 377 yield reduction following 25/ defoliation one week before harvest while during flowering yield reductions started only between 337 50/ defoliation Studies at CIAT by Dr Gálvez (CIAT 1975) showed that defoliations between 30 and 45 days after planting (begining of flowering to end of the flowering period) were the most damaging Yieldlosses over 35/ only occured when more than 607 of the foliage was removed Our studies on leafhoppers a sucking insect indicated a 6 4/ yieldloss per each additional nymph tolerated per leaf (CIAT 1975) These data indicate that beans can withstand certain levels of defoliation before yieldlosses occur

The insects attacking beans

Ruppel and Idrobo (1962) list a total of 208 insects attacking beans Bonnefil (1965) considers about 15 insect species to be economically important in Central America Most bean pests are poliphagous and attack several cultivated legumes and other crops

These are the most important bean pests according to the lieterature and from my own observations

Insects attacking seedlings

1 Seedcorn maggot *Hylemya* sp

2 Cutworms whitegrubs crickets and centipedes

3 *Flasmopalpus lignosellus*

Leaffeeding insects

1 Chrysomelids (*Diabrotica* sp *Cerotoma* sp etc)

2 Lepidopterous leaffeed rs (*Estigmene acrea* *Urbanus proteus*, *Hedylepta indicata* etc)

3 - Mexican bean beetle (Epilachna varivestis)

Sucking insects

1 - Leafhoppers mainly Empoasca kraemeri

2 Mites (Tetranychus sp and Polyphagotarsonemus sp)

3 Whitefly Bemisia tabaci

4 Aphids

Pod attacking insects

1 Bean pod weevil Apion godmani

2 Epinotia opposita Laspeyresia sp Maruca testulalis

3 Heliothis sp

Stored bean attacking insects

Zabrotes subfasciatus

Acanthoscelides obtectus

This division cannot be strictly maintained as eg the Mexican Bean Beetle Chrysomelids and Trichoplusia sp will attack young pods too while Epinotia and Heliothis may attack leaves and buds

Distribution and most important insect pests

The bean pest complex varies greatly over Latin America but is not well documented According to a survey by Gutierrez et al (1975) the most widely distributed insects in Latin America are Empoasca species with Chrysomelids (mainly Diabrotica balteata) cutworms and crickets pod damaging insects (especially Apion godmani) and storage insects of decreasing levels of importance They give no estimation of the economic importance of these pests (Table 1)

Bonnefil (1965) lists Empoasca as the most important bean insect in Central America followed in importance by the Crysomelids (Table 2)

The distribution of the most important pests is given in Fig 1 This is a simplified distribution as the Mexican Bean beetle for example occurs in Mexico the Guatemalan highlands and Nicaragua And the bean pod weevil (Apion) is still a problem as far South as the North of Nicaragua Snails not listed here are a severe problem in the bean culture of El Salvador and Honduras

The stored grain insects Acanthoscelides obtecus and Zabrotes subfasciatus are found in all areas of Latin America A obtectus occurring primarily in the higher latitudes in both fields and warehouses (Chile Peru Colombian mountains) while Zabrotes subfasciatus is primarily found in the stores of warmer areas

Losses from insects

The potential losses from insect damage vary greatly among regions planting dates varieties and cultural practices In studies by Miranda (1971) losses due to insects alone ranged from 33 83 percent when non treated plots were compared with treated plots

Mancía et al (1974) reported losses from Apion in El Salvador as high as 94 percent These are some extreme examples Of 16 insecticidal trials reported in Central America the average yieldloss in the control as compared with the highest yielding insecticidal treatment was 47 25/ The highest losses are reported from Empoasca p (Table 3) These figures probably overrate the importance of insects in the bean culture as most insecticidal trials are made during highest levels of attack

In 6 insecticidal tests with the susceptible variety to leafhoppers Diacol Calima at CIAT losses due to insect attack ranged in the wet season from 14 237 averaging › In the dry season these ranged from 73 95/ averaging 76/ (Fig 2)

We believe that losses from diseases because of the rainfed crop are more severe than those from insects

Insects attacking the seedling stage

1 Seed corn maggot Hylemya cilicrura (Rond) (Diptera Anthomyiidae)

The seed corn maggot is a bean pest in Chile and Mexico and in areas in of the USA and Canada The genus has been named Delia Phorbia and Hylemyia The adult fly resembles the housefly Other species re ported from beans are H platura and H liturata H cilicrura and H li turata are closely related and difficult to distinguish (Miller and Mc Clanahan 1960) McLeod (1965) separated the species by differences in nutritional requirements and infertility of interspecific hybrids Ovi position takes place near seeds or plants in the soil Larvae feed on bean seeds or seedlings and pupate in the soil (Miller and McClanahan 1960) At 21-23^{o}C Harris et al (1966) obtained an incubation period of 2 days a larval stage of 9 2 days and a pupal stage of 8-12 days They found evidence that above 24^{o}C pupae enter estivation The average female produced 268 4 eggs Adult females were observed to be abundant on dandelion and honeydew of aphids Adults are less active above 32^{o}C Swarming and hovering is also observed The larvae attack many host plants beans corn potatoes beets pepper tobacco and vegetables and others (Miller and McClanahan 1960) The adults are attracted to newly disturbed soil and organic matter in which their larvae can develop eg decaying spinach The adult population is therefore not necessarily related to seed damage severity

Damage

According to Hertveldt an Vulsteke (1972) 20 30/ loss in germination was obtained with 1 2 larvae per bean seed while 2 3 larvae reduced germination 50 percent Damage including poor germination and production of deformed beans called baldheads results as larvae feed between cotyledons often injuring the embryo Also larvae can penetrate the stem of germinating seeds and damage the plants

Control

Late planting causes rapid germination of seeds and therefore less exposure time to Hylemya In three one month interval plantings in Chile the percentage of plants germinated but damaged by Hylemya reduced from 26 6 to 9 2 and to 1 5/ respectively (C Quiroz pers comm) Humid orgainic matter soils are more likely to attracts females especially when recently ploughed In Mexico it was shown (Guevara 1957) that soils covered 20 min after sowing carried allready 50/ of the final population

Biological control is reported to operate only at low levels (Miller and McClanahan 1960)

Resistance to seed corn maggots is reported by Vea and Eckenrode (1976) To insure a high larval populations necessary for screening they tried to increase natural infestation by planting at high fly population and by band applications of meat and bone meal The varieties C 2114 12 and PI 165426 showed 0 and 47 stand loss while the susceptible variety Sprite gave 887 loss Percent emerged seedling damage was lowest on PI 165426 and C 2114-12 White seeded varieties were susceptible Rapid emergence and hard seed coats contribute to resistance Guevara (1957) also reported differences in level of attack by

Hylemya Black seeded varieties were the least and yellow colored ones the most attacked

Chemical control

Granular insecticides like diazinon carbofuran chlorpyrifos applied in the furrow effectively control the maggot Slurry applications of these products also were effective (Eckenrode et al 1973) C Quiroz (pers comm) obtained better control with granular carbofuran in Chile at planting then with aldrin a commonly used product

2 Cutworms, Whitegrubs, Crickets and Centipeds

Many species of cutworms damage beans Their larvae cut the stem of young seedlings causing stand loss Older plants can be damaged by girdling or partial girdling of the stem thus rendering plants susceptible to breakage by the wind Some common cutworm genera are *Agrotis* *Feltia* *Spodoptera* and *Prodenia* Biology and control is discussed by Metcalf and Flint (1972)

Cutworm attack in beans occurs erratically and is difficult to predict Therefore we prefer to control cutworms with baits instead of using the common preventive chemical control with aldrin These baits are applied in the late afternoon near the plants A formulation may be 25 kg sawdust (or corn flour) 3 l molasse and 1 l dipterex per hectare This formulation also controls crickets and centipeds

In preliminary trials at CIAT it appeared that beans may not be a preferred host for *Spodoptera frugiperda* one of our most important cutworm species In associated cropping of beans with maize cutworm damage in beans was near 0 while in corn alone cutworm damage was signi ficantly more (71 3/) than in corn associated with beans

Whitegrubs mainly a problem in newly prepaired land after pastures are best controlled by proper land preparation and chemically with carbofuran or disulfoton band applied at 0 9 kg/AI per hectare or 1 25 kg aldrin incorporated in the soil

3 Elasmopalpus lignosellus (Zeller) The lesser corn stalk borer (Lepidoptera Pyralidae)

Elasmopalpus lignosellus is a serious bean pest in parts of Peru (F Avalos pers comm) and Brasil (Costa and Rossetto 1972) while it has been recorded on beans elsewhere in Latin America It attacks a variety of cultivated plants and weeds like corn sugarcane cereals legumes nutgrass etc

Damage

Larvae damage the seedling entering the stem just below ground level and tunneling upwards causing plant mortality and subsequent standloss

Biology

The adult places its eggs singly on the leaves or stems or in the soil The 6 larval instars are passed in 13 24 days and then pupate in the soil (Leuck 1966) Dupree (1965) found little evidence of stem boring activity prior to the 3rd instar

Control

Best control is achieved with clean fallowing for prolonged periods or heavy irrigation (Wille after Campos 1972) Leuck and Dupree (1965) recorded egg parasitism and larval parasitism by species of Tachinidae Braconidae and Ichneumonidae (1 larvae collected from cowpeas) Chemical control due to larval habits should be at planting and especially directed near the seeds

Leaffeeding insects

1 Chrysomelids

Many species of Chrysomelids attack beans in Latin America Bonnefil (1965) lists the genera Diabrotica Cerotoma Andrector with D balteata LeConte as probably the most abundant species Ruppel and Idrobo (1962) list 36 species of Chrysomelids with additional genera Epitrix, Chalepus, Colaspis Maecolaspis Systena and others This review will concentrate mostly on D balteata the banded cucumber beetle

Damage

Most damage by Chrysomelids is inflicted in the young seedling stage when a relatively high percentage of foliage is consumed Larvae may damage bean roots and root nodules of Rhizobium Sometimes adults feed on the young pods Chrysomelids are known to transmit the bean rugose mosaic virus (Gamez 1972)

Biology of D balteata

Females start ovipositing when 1 2 weeks old Eggs are laid singly or in clusters of up to 12 eggs in cracks in the soil or under plant debris Over 800 eggs per female were obtained in an adult lifespan lasting from 17 44 days with an average of 26 4 days Oviposition usually occurs at intervals of a few days Eggs hatched in 8 2 days at about 21°C and 5 8 days at about 27°C The three larval stages are passed in 10 5 days on soybean roots at 27°C The pupae are formed in a pupal cell in the ground and this stage lasts 7 2 days at this temperature (Pitre and

Kantack 1962) Young and Candia (1963) obtained an incubation period of 5 9 days a larval period of average 17 days and prepupal and pupal stage of 9 17 days The maximum egg production of adults that fed on bean leaves was 144 per female Pulido and Lopez (1973) found an average of 326 eggs when adults were fed soybean leaves but this increased to 975 when fed soybean leaves flowers and young pods When fed on soybean leaves the length of the adult life ranged from 69 112 days Harris (1975) described large adult color variation within D balteata but especially in Cerotoma fascialis

While the adults feed on many plants including corn (silk and pollen) and bean leaves the larvae develop on roots of among others corn and beans Pulido and Lopez (1973) list 32 host plants Of these corn and beans with 5 other plant species are listed as hosts for adults and larvae Harris (1975) lists common bean field weeds in the Cauca Valley as larval hosts These are Amaranthus dubius Leptochloa filiformis Echinochloa colonum and Rottboellia exaltata He found adult D balteata and C fascialis to prefer beans followed by soya peanut cotton and maiz Young (1959 1960) reported from Mexico that D balteata adults have a feeding preference for young bean plants and an oviposition preference for young corn plants

Control

Predation of adult chrysomelids is often observed in the field by Reduviids while Young and Candia (1963) reported a T chinid adult parasite

Chemical control is recommended with carbaryl at 1 1 5 kg AI/ha or malathion and dimetoate

2 Lepidopterous leaffeeders

S veral species of Lepidoptera develop on beans Although larvae are readily found on beans populations are usually too low to cause economic damage Their level of biological control is high

1 Urbanus (Eudamus= Goniurus) proteus (Linn) the bean leafroller (Lepidoptera Hesperiidae)

The bean leafroller is widely distributed on beans from the USA to Brasil Greene (1971 a) calculated that yield reduction occured when over 725cm2 area per plant was removed The first three larval stages of the leafroller can not reach this reduction Of the 4th instar which consumes average 27 7 cm^2 26 larvae per plant must be present And of the fifth instar which consumes 162 4 cm^2 foliage 4 4 larvae per plant must be present to reduce yields Assuming 50 percent mortality per instar this would require to 1 0 8 eggs per plant a population seldomly reached

Larvae have frequently been found on beggar weed (Desmodium tortuosum) and Desmodium sp (Quaintance 1898)

The butterfly puts its eggs 1 6 per leaf on the leaf undersurface and the young larvae folds and ties a small section of the leafmargins together however it often feeds elsewhere In this chamber pupation also takes place The larvae are characterised by 3 dorsal longitudinal lines and a large red brown head capsule (Quaintance 1898)

Greene (1971 b) reported that 4 percent of the eggs reached the 5th instar in the field At 29 5 C eggs hatched in 2 8 days the larval stage was passed in 14 7 days and the pupal stage in 8 7 days He observed large numbers of adults on Lantana camara flowers and is flowering bean fields

Control

Control is seldom justified

2 - Saltmarsh Caterpillar Estigmene acrea (Drury) (Lepidoptera Arctiidae)

The saltmarsh caterpillar is regularly found on beans however it is more a cotton pest in the USA where they also attack lettuce and sugarbeets (Stevenson et al 1957) Young and Sifuentes (1959) name as preferred natural hosts Amaranthus palmeri Wats and Physalis angulata L while it also occurs on beans cotton maiz horticultural crops soybean sesame tobacco and several weeds

The adult moth places its eggs in masses upto 1000 eggs in total The larvae develop in 17 19 days on Amaranthus The young larvae aggregate and isolated bean plants can be skeletonized Older larvae are solitary Their body is covered with setae The larvae pupate on the soil in plantdebris The adult is a white moth with black dots on its wings (Young and Sifuentes 1959)

Individual plants on which the gregarious stages are passed may be severely damaged though economic damage is seldom on beans In the Cauca Valley 12 Dipterous parasite species contributed to an average parasitism of 30 6/ of the larvae (Rodas 1973) Young and Sifuentes (1959) reported Coccinellid and Malachiid egg predators and Reduviids as larval predators Several Hymenopterous parasites of larvae have been reported Chemical control is seldom justified

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

Hedylepta indicata is a pest on beans soybeans and other legumes in Colombia (García 1975) and other area of South America (Ruppel and Idrobo 1960) Larvae live between leaves woven together well protected from chemical control

Biology and damage

Adult moths oviposit on leaf undersides The female lays an average of 330 eggs which hatch in 3 5 days The green larvae develop in minimal 10 6 days then pupate and after 5 1 days minimum the adult emerges according to studies in India (Kapoor et al 1972) The larvae feed on parenchyma of the leaves woven together

Control

The level of biological control is very high Garcia (1975) found over 85 percent larval parasitism by Toxophoroides apicalis (Hym Ichneumonidae) An Carabeid was found predating larvae of H indicata This Carabeid oviposits among the frass of the caterpillar and predates on them The whole lifecycle develops between the leaves woven together by Hedylepta (Lenis and Arias 1976)

Chemical control is most effective with methamidophos (0 4 1 AI/ha) and dicrotophos (0 6 kg AI/ha) (García 1971) but is seldom justified

3 The Mexican Bean Beetle Epilachna varivesti Muls (Coleoptera Coccinellidae)

The Mexican bean beetle is mainly a soybean pest (Turnipsed and Kogan 1976) It is a bean pest in Mexico Guatemala and El Salvador in the latter in the wet season The Mexican bean beetle differs in behaviour from Chrysomelid in that larvae and adults feed on foliage stems and young pods It is phytophagous in habit within a family of insects that are predators Synonyms are

Epilachna corrupta Mulsant 1850 and E masculiventris Bland 1864

Hostrange lancia and Roman (1973) found as hosts in El Salvador _ vulgari , P lunatus P atropurpureus Vigna sinensis and Glyci __ max Al o beggarweed i reported as h st Tunner (1932) reared the beetle on Ph vulgaris coccineus and lunatus on V sinensis and Doli h__ lablab On the latter high larval mortality occurred He clas sifi l P aureus inmmune as well asVicia faba _ aureus mungo and radiatus are less preferred hosts than P vulgaris (Wolfenbarger and Sleesman 1961 l Augustine et al 1964) The latter authors attribute this mainly to sucrose concentration acting as arrestants combined with differences in olfactory action of the foliage LaPidus et al 1963 confirm these results from seeds of resistant and susceptible plants

Damage

Young larvae feed on the leaf undersurface and usually leave the upperepidermis undamaged while older larvae and adults often feed through the leaves Third and 4th instar larvae consume more than adults Stems and pods are eaten with high population densities The larvae do not chew the leaftissue but scrap the tissue up compress it and swallow the juices only De la Paz et al (in press) infested plants ranging from 41 71 days after planting with 0 25 larvae per plant The larvae were allowed to pupate then infestations were with drawn They obtained the most damage at early infestations and also obtained the regression of population size and plantage on yield At the infestation at 41 days with 25 larvae reduced yield 93/ more when compared with infestation at 71 days

Biology

(Thomas 1924 Mancía and Roman 1973)

The adult female beetle begins oviposition 7 15 days after pupa tion and lays its eggs on the leaf undersurface in groups ranging from 4 76 averaging 52 orange yellow eggs (Thomas 1924) Mancía (1973) obtained an average of 10 egg batches with 42 8 eggs per batch average varying from 36 54 Eggs hatch in 6 days the 4 larval stages are pas sed in 15 16 days the prepupal stage in 2 days and the pupal stage in 6 7 days The yellow larvae are covered with branched spines The pupation tal es place attached to the leaf undersurface Adults are copper colored with 16 black spots They live 4 6 weeks

In El Salvador the beetle forms 4 generations on beans from May to November but it is not known where it overwinters (Mancía and Roman 1973) In the USA the adults hibernate usually in woodland bean debris etc often gregarious

Biological control

Predators of eggs and of the first larval instar are Coleomegilla maculata De Ceer and Hippodamia convergens Guen Adults are attacked by Coccipolipus macfornanei (Mancia and Roman 1973) while the mite Coccipolipus epilachnae Smiley is also reported as a predator in El Salvador (Smiley 1974) On soybeans Pediobius foveolatus (Hymenoptera Eulophidae) reduced Mexican b in beetle populations (Stevens et al 1975)

Cultu l Control

Cleaning plantdebris and deep ploing are recommended to control the insect While reduced plant density decrease beetle injury Number of eggmasses per plant decrea l from 1 07 to 0 15 when plantspacing increased from 5 to 20 cm Similarly percent yield reduction decreased from 22 6/ to 11 37 and poddamage also decreased (Turner 1935)

Resistance

In free cho ce cage studi s on 60 varieties of beans and limabeans Idaho Refugee and Wade showed resistance with only 25 2 percent foliage destroyed while Bountiful lost 61 7/ foliage The number of eggs and eggmasses as well as adult weights were reduced more than 50 percent when beetles were reared on resistant lines as compared with suscept ible ones (Campbell and Brett 1966) Wolfenbarger and Sleesman in countrast (1961 d) did not locate resistance in P vulgaris genetic material They also tested Idaho Refugee and Wade which ranked in their test susceptible (8 5 in a 1 9 scale with 9 most susceptible) They found based on leaffeeding damage highest level of resistance in Vigna aureus Nayar and Fraenkel (1963) hypothesize that phaseolunatin a cyanogenic glycoside attracts beetles at low concentrations but may cause resistance in varieties with high concentrations of this compound

Garcia and Sosa (1973) obtained resistance to the beetle in P vulgaris and P coccineus The entries Puebla 84 (P coccineus) Guanajuato 18 and Zacatecas 48 (P vulgaris) showed resistance Least eggs were laid on Gto 18 and Oax 61-A They concluded that antibiosis and non preference played a role

Chemical control

Cadena and Sifuentes (1969) obtained most effective chemical con trol with carbaryl (1 5 kg A I /ha) Malathion and methylparathion were much less effective They suggested the first application to be made at 25 adults/ha and the secoı i to be combined with Apion control and possibly a third application U S farmer recommendations are to spray when 1 beetle or eggmass is found per 6 foot row The beetles are counted on the ground after slapping the plant Hagen (1974) obtained 10 weel effective control with granular insecticides applied at planting namely disulfoton carbofuran phorate aldicarb and dasanit

Sucking insects

1 Leafhoppers Empoasca kraemeri Ross and Moore (Homoptera Cicadellidae)

Empoasca kraemeri is the most important insect pest of beans It is reported from Florida and Mexico south to Perú While E fabae and E solana occur in the USA and Canada but not in South America (Ross and Moore 1957) Other Empoasca species in South America are E prona E aratos, E phaseoli (Bonnefil 1965) Empoasca kraemeri does not transmit virus diseases the only Empoasca species known to have this attribute being E papaya Oman which transmits bunchy top virus of papaya while the only leafhopper known to transmit a bean virus is the beet leafhopper Circulifer tenellus transmitting bean curly top virus

E kraemeri is a phloem feeder like E fabae The plant damage shows as leafcurling and chlorosis stunted growth and greatly reduced yield to complete crop loss

Biology

Most studies on biology of leafhoppers and damage on beans and potatoes have been done with E fabae in the USA In studies on the biology of E kraemeri on beans (Wilde et al 1976) eggs hatched in

8 9 days and the five nymphal instars were passed in 8 11 days The females live 65 days average and the males 58 days Oviposition per female ranged from 13 to 168 eggs averaging 107 2 eggs The eggs are laid singly in leafblades petioles leaf tissue or stems of the bean plant Depending on variety from 50 82/ of the eggs per plant were found in the petioles

The damage may be caused by physical injury although some speculate a toxin is involved

Ecology

Leafhopper attack is more severe during hot dry weather and with insufficient soil moisture This was already recognized in 1922 for E fabae The same number of leafhoppers during humid weather with ample soil moisture caused less damage than under moisture stress (Beyer 1922) This has an influence on the planting date for controlling leafhoppers populations Miranda (1967) obtained 1182 kg/ha of dry beans when planted 21 of Dec as compared with only 121 kg/ha when planted January 21 In CIAT similar results were obtained Our screening for Empoasca resistance is usually made in dry or semi dry seasons while bean production is recommended from the insect control point of view in the wet season CIAT 1973) However plantings in the late part of the dry season sometimes stays relatively free of hopper damage and the leafhoppers collected in the later p rt of the dry season caused relatively less damage than those in the early dry sea on We assume that high temperature and waterstress aggravate Empoasca damage In Colombia it is most important in the moderate climates from 1000 1500 m (Ruppel and DeLong 1956)

Other important ecological tools can be used to reduce leafhopper populations and damage In our bean plots with increasing weed density from 0 100 percent soil cover by weeds leafhopper adult and nymphal populations decreased 43 0/ and 70 1/ respectively when weed free plots were compared with plots with 100/ soil cover of weeds This reduction in Empoasca population in increasing complex ecosystems is not ascribed to increased parasite or predator populations The bean yields resulted equal in weed free plots as compared with weedy plots The decrease in Empoasca population may have been counterbalanced by the increase in weed competition

Similarly when 16 m^2 bean plots were surrounded by borders 1 m wide of the principal grassy weeds of the bean weed association experiment (Eleusine indicata and Leptochloa filiformis) Empoasca populations were significantly reduced Corn has also a reducing effect on Empoasca when beans are associated with corn Corn planted 20 days before beans reduced the leafhopper populations significantly (72 3 adult leafhoppers per sample on 80 bean plants as compared with 133 when maiz and beans are planted at the same date) In contrast when beans are planted prior to or after corn this reduced the whorl worm (Spodoptera frugiperda) populations significantly (7 8 larvae per 40 corn plants when beans were planted 20 days before corn and 25 8 when planted at the same day)

Mulching and shading also reduced initial Empoasca populations as compared with untreated plots The recollection at 20 days after planting measured 18 adults average in mulched plots with 103 on non mulched plots At 45 days after planting the beans in the mulched plots were so much vigorous that the highest adult counts were made in mulched plots

Host plants

Leafhoppers breed on many cultivated and non cultivated plants We have collected in Colombia 200 plants on which *Empoasca* nymphs were found the species are pending determination

Varietal resistance

Varietal resistance to leafhoppers in beans was reported in the USA as far back as 1922 (Beyer 1922) He reported that the variety Wells Red Kidney was suffering less damage than other varieties tested Tissot (1932) reported equal leafhopper populations in the resistant or susceptible varieties a finding consistant with our results to date

Leafhopper *E fabae* resistant varieties (Idaho Refugee and U S Refugee No 5) (Gates 1944) are resistant in current testing to *E kraemeri*

In the USA Wolfenbarger and Sleesman (1961) have published on resistance to *E fabae* They evaluated 1619 lines PI 151014 with 0 3 nymphs per leaf had the lowest count while Dutch Brown with the highest count had 19 7 nymphs per leaf They obtained no correlation between number of epidermal hairs and nymphal population per variety and reported 90 96/ correlation between nymphal counts and damage scores Varieties with high nymphal populations and low hopperburn ratings were also observed (Wolfenbarger and Sleesman 1961 a) The same authors (1961 b) published data showing relationship between leafhopper resistance and plant characteristics like tallness resistance to BCMV pink or mottled colored seed intermediate in maturity The lowest nymphal counts were obtained on *P aureus* and *P lunatus* and *V mungo* These species are not currently crossable with *P vulgaris* From interspecific crosses between P vulgaris and P coccineus they suggested that resistance is inherited recessively (1961 c)

Chalfant (1965) tested 28 varieties for resistance and finding about 50 percent yield reduction when protected and unprotected plots were compared regardless of the degree of suscep ib lity of the varieties Mc Farlane and Rieman (1943) also reported resistance to E fabae in beans

We have a major screening program for varietal resistance to Empoasca kraemeri in CIAT with about 8 000 accessions of P vulgaris so far tested for resistance Our selection scheme is based on elimination of susceptible materials We plant 5 test varieties between rows of ICA Tui a standard resistant variety and use Diacol-Calima as susceptible borders ICA Tui is always rated as grade 2 in a 0 5 damage scale Our most resistant bean material yield ed equal in the wet season with insecticidal protection as compared with non protected plots while susceptible varieties suffered losses of up to 40/ Such resistance levels have given good protection in areas eg in Peru but in the dry season at CIAT they are not high enough and a breeding program is underway to increase resistance level

We do not obtain correlations between nymphal counts and damage scores (Wolfenbarger and Sleesman 1961 a Chalfant 1965) Concluding that our populations are much higher than in the USA and that susceptible varieties receive so much damage (and therefore a high damage score) that leafhoppers avoid them for oviposition

The resistance mechanism is not clear but is probably tolerance A low degree of non preference was found in ICA Tui but disappeared in no choice tests No antibiosis has been found (Wilde and Schoonhoven 1975)

An other resistance mechanism may be present in the form of capture of nymphs in hooked trichomes as shown by Pillemer and Tingey (1976) In our study with E kraemeri we obtained lower nymphal mortality on hooked trichomes then reported We explain this by decreased trichome density on expanded leave By the time the leafhoppers eggs have hatched the leaves in which they were laid are fully expanded

Mites

Spidermites Tetranychus desertorum Banks (Acrina Tetranychidae)

The spidermites usually attack beans near to their physiological maturity and rarely influence yields and thus justifying control measures In Colombia the important species is T desertorum while T telarius is reported from Argentina (Ruppel and Idrobo 1962)

The biology of T desertorum was studied by Nickel (1960) who concluded that the low temperatures limit geographical distribution of the pest In laboratory conditions in Colombia the incubation period lasted 4 8 days the inmature stages 6 2 days and the female oviposited an average of 4 1 eggs per day for 15 days (Piedrahita 1974) This is a slightly slower development rate than cited by Nickel and is also a lower oviposition rate

Hostrange

T desertorum has a wide hostrange Nickel (1960) lists 13 hosts from Paraguay

Control

Varietal resistance was found in Oregon 58 R (J G Rodriguez pers comm) Biological control is effective by several predator mites in detailed studies however chemical control may be mostly utilized Resistance to pesticides causes changes of products recommended Gonzalez (1963) recommend uniform restricted planting dates and chemical control with folimat mixed with metasystox and tedion with C 1414 On Lima beans Wilcox and Howland (1960) recommend thimet and di syston as granular soil applied insecticides

Polyphagotarsonemus latus (Bank) (Acarina Tarsonemidae)

Although little known a second mite species P latus attacks beans and may be more damaging Again attacks occur mostly post flowering The mite genus is synonym to Tarsonemus Neotarsonemus and Hemitarsonemus It is a small palegreen mite difficult to see without magnification

Biology

The mite has a short lifecycle composed of egg larva pseudopupa and adult stage each period lasting at 27°C 1 3 2 and 2 days respectively (Flechtman 1972) In CIAT (1975) under laboratory conditions (22 28°C) the duration of these periods was 2 1 and 1 day respectively Females lived 15 days and laid 46 3 eggs average Males live slightly shorter that is 12 days The mites are a problem during humid warm weather

Distribution and host range

The mite is reported as a bean pest in Brazil (Costa and Rossetto 1972) and in the Cauca Valley of Colombia where is a serious pest In Peru and Central America we also observed its presence Many other hosts besides beans are known including potatoes (Doreste 1968) tomato Centrosema and Dolichos (Cromroy 1958) green pepper dahlia and cotton (Hambleton 1938) We found this mite attacking several common weeds in bean fields

Damage

Yield losse of 56/ have been recorded at CIAT (1975) based on in dividual plant measurements

Symptoms

leaves roll the edges upward and get a shiny appearance Depending on the variety the leaf undersides turn purplish Young leaves do not develop normally and remain stunted often from yellow to gold colored The pod can be attacked and covered with a brownish wound tissue Some varieties show a downward curling of leaf edges and a darkening of the leafblade Symptoms are easily mistaken for virus induced symptoms or by mineral deficiencies

Control

In our experiments monocrotophos carbaryl and elosal gave good contr l Costa (1970) recommends for cotton carbophenothion chlorbenso lato chlorfensulfide and endosulfan Apparently mite populations are sti mulated bv dimethoate (Harris 1969)

3 Whiteflies

Five species of Aleyrodids live on beans in the Americas They are Bemisia tabaci B tuberculata, Tetraleurodes acaciae Trialeurodes abutilonae and T vaporianum These species also have other legume and non leguminarias hosts B tabaci is a vector of bean virus diseases namely bean golden mosaic bean chlorotic mottle and possibly more The species has a wide range of synonyms and some races are identified based on their virus transmission characteristics Golden mosaic is found the most limiting factor in bean production in certain areas in C America and Brasil In this review no attention is given to the virus transmission aspect of whiteflies

Biology

Eggs are laid singly or in groups on the leaf underside with the egg pedicel inserted in the epidermis From egg to adult requires about 3 weeks The oviposition ranged from 25 32 eggs average per female The 3 immature stages and also the pupal stage are fixed to the leaf underside Identification is made on the immature stage (Russell 1975)

Control

Large differences exist in Guatemala on intensity of attack by white flies according to geographical zone and planting data (Alonzo 1975) Chemical control is most effective as measured in percent mosaic infested plant with metasystox and monocrotophos (foliar applied at 15 and 30 days after planting) or thimet and furadan granular applied at planting date (Alonzo 1975) In El Salvador Mancia et al (1973 b) report best control with the systemic insecticides temik followed by carbofuran and thimet

4 Aphids

Several aphid species attack bean plants Their direct damage is assumed to be of no importance but their ability to transmit bean common mosaic virus makes them economically important pests Further reading is referred to Zaumeyer and Thomas (1957) He reported the following aphids able to transmit bean common mosaic virus

Aphis gossypii *A medicaginis* *A rumicis* *A spiraecola* *Brevicorne brassicae* *Hyalopterus atripilicis* *Rhopalosiphum pseudobrassicae*

Macrosiphum ambrosiae M solanifolii M pisi and Myzus persicae Costa and Rossetto (1972) list aphids occurring on bean foliage and roots in Brasil In CIAT control of bean common mosaic is sought by incorporation of resistance genes to the virus into beans

It is interesting to note that high aphid mortality occurs when captured by hooked hairs on bean leaves Capture percentage and number of hooked hair increased when plants were grown under dry conditions as compared with ample moisture (de Fluiter and Ankersmit 1948) Similarly reported by Mc Kinney (1938) for Myzus persicae and thrips

Pod attacking insects

1 Bean pod weevil Apion godmani Wagn (Coleoptera Curculionidae)

Apion godmani is a serious bean pest in Central America Mancia et al (1973 b) report that in El Salvador damage of up to 94 percent of the beans lost Attack is most severe during the rainy season when 2 generations are formed He considers it during the wet season in certain areas the most serious bean pest of El Salvador

The weevil is a bean pest in Mexico Guatemala El Salvador Honduras and Nicaragua however it has also been reported on beans in Colombia (A L A E 1968)

In Mexico it is reported to be in certain regions more severe than in others being especially important in the altiplano the center and the south of the country during the rainy season (McKelvey et al 1951) Enkerling (1957) found up to 90 percent of the crop destroyed in certain areas of Mexico In Mexico A aurichalceum is second in importance to A godmani The oviposition behavior of this species is different in that the female group about 35 eggs together in the distal portion of a pod allowing the other seeds of this pod to escape attack (McKelvey et al 1951)

There are several other less important Apion species which also attack beans (a o A aurichalceum A perpilosum A calcaratipes A germanum A griseum) and one of another genus Chalrodenus aenerus Apion godmani ha also been reported as Trichapion godmani (Wagn) (Mancía 1973 b) (McKelvey et al 1951) Other host plants than P vulgaris include Dalea sp Desmodium sp Rhyncosia sp and Tephrosia sp (Mc Kelvey et al 1947)

Biology

The adult weevil is tiny black about 2 9 mm long During the wet season 2 generations are formed and possibly a third during the dry season Overwintering sites could not be found in Mexico (McKelvey et al 1951)

Under laboratory conditions at 20 8°C and 75/ RH average (Mancía 1973 b) stated that the egg stage of the weevil lasted 5 days The three larval instars are passed in 6 days while the prepupal and pupal stage last 2 and 9 days respectively The adult insect can stay 3 4 days in the pupal chamber however usually emerges immediately after pupation He observed adult longevity between 10 days and 11 1/2 months averaging 2 3 months

Adults mate upon emergence which may be repeated several times Mancia (1973 b) counted a maximum of 392 eggs per female with 4 6 eggs laid per day The preoviposition period lasted 10 days McKelvey et al (1951) report incubation period 12 days larval stages 22 34 days prepupa ? days pupa 6 10 days and adults live from 2 3 months

Damage

Adults start appearing when bean plants are still small and occasionally cause light feeding damage to the 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 seed in formation in which it deposits an egg which measures about 0 2 x 0 3 mm in size These spots become visible as white colored hiperplastic deformations The adult exit holes in the podwall can also be found (McKelvey et al 1947 McKelvey et al 1951) Attacked young pods can abort (Enkerling 1951)

The larvae bores down in the mesocarp of the podwall to start feeding on the developing seed in its second instar leaving the hylum intact Normally one larva per seed is found however during heavy infestations up to 3 5 larvae per seed were found with a maximum of 22 larvae per pod (Mancia 1973 b) McKelvey et al (1947) reported also one larva per seed although he found up to 7 per seed and up to 28 per pod The larvae live in a feeding chamber Larvae cannot feed on mature seed (McKelvey et al 1947)

Biological control

Mancia (1973 b) encountered 2 Braconid parasites of Apion larvae one belongs to the genus Triaspis However a seed containing a parasitized Apion larvae is destroyed

Cultural control

In 2 weekly plantings McKelvey et al (1947) found no influence of planting data on level of infestation while continued studies showed a tendency for lower infestations in early and late plantings

Varietal resistance

Guevara (1962) tested 6 varieties finding Pinto 168 the most resistant In this variety 4 2/ of the bean seeds infested while the most susceptible variety Negro Mecentral showed 67 2/ of the seeds infested The varieties Puebla 152 (with 17 0/ attack) and Mexico 228 7 (with 12 0/ attack) rated intermediate resistant The variety Pinto 168 yielded equally with and without chemical protection while Puebla 152 and Mexico 228 7 needed 2 sprays and the susceptible test variety Negro Mecentral needed 3 or 4 applications to control the weevil

Of 14 varieties tested by Ramirez et al (1959) Negro 151 was the most resistant with 84 Apion larvae found per 60 pods This was followed by Bayo 164 (with 90 larvae) and Pinto 168 (108 larvae) Canocel the most susceptible variety had 806 larvae per 60 pods Similarly for adult counts per pod Canocel was the most susceptible with Negro 151 Chapingo 55 III 7 Pinto 168 and Amarillo 154 the most resistant varieties in decreasing order

Mancia (1973 a) tested 2004 entries of P vulgaris for resistance to Apion He obtained 9 highly resistant varieties and 2 less resistant without giving however their identification The highly resistant entries had 0 87 4 86/ of the seed damaged while the most susceptible entry showed 43 3 and 94/ seed damage

McKelvey et al (1951) showed that in 4 years testing the varieties Puebla 32 Hidalgo 6 Puebla 2 and Hidalgo 24 continually showed lower infestations of the 8 varieties tested Varieties Pue 32 A 2 Hgo 33 A 1

Hgo 28 A 2 Pue 20 B 2 Hgo 36 A 1 Gto A 2 Gto 10 A 5 and Hgo 14 A 3 (Pue= Puebla Hgo= Hidalgo) combined high yield with resistance to *Apion*

The only documentation found on breeding for insect resistance in beans is in Mexico for *Apion* resistance (Guevara 1957) He evaluated for resistance based on percent seeds infested per 100 pods The resistance sources were Pinto 162 and 168 Amarillo 153 154 and 155 EAP 88B and Negro 151 and later Hidalgo 15A and 24 Puebla 2 and 57 B 3 Tlax 2 1 C and Amarillo 156 and 164 and Negro 157 (Guevara 1969) Best results were obtained in resistance to *Apion* with crosses involving Hidalgo 6 and Puebla 32 Although no details are given on resistance mechanism or inheritance highly resistant lines were obtained out of 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 (1973) testing 14 varieties found resistance in Negro 66 Jamapa Canario 101 and 107 to *Apion*, *Empoasca* and Mexican bean beetle resistance to *Apion* and *Empoasca* in Ojo de Cabra and Negro Criollo and to *Apion* only in Bayomex Delicias 71 and Querétaro 183 1

Mancia (1973 a) states that immunity to *Apion* is found in *P multiflores* (=*P coccineus*)

Chemical control

Although there is great promise in the use of resistant varieties chemical control remains important Of several products tested monocrotophos lannate methyl parathion and sevin gave effective control while of the granular insecticides tested furadan at 2 49 kg AI/ha at planting time gave best control (Mancía et al 1973 a) With methyl parathion he obtained best and most economical control with 2 sprays one at 6 days after flower initiation repeating it 7 days later With one spray most effective control was obtained if applied 13 days after flower initiation (Mancia et al 1974)

2 *Epinotia opposita* Heinr (Lepidoptera Olethreutidae)

An important insect pest in Peru and Chile is *Epinotia opposita* (=*E aporema*) as leaf terminal bud and pod feeder Wille (1943) considers it the most important legume pest of Peru from sealevel up to 2 500 m altitude Its larvae feed on or in the terminal or lateral buds or perforate the stems and pods In alfalfa young larvae web the leaves together in which they live The larvae weave the excrements together and push them out of the feeding canals In Colombia there is also flower damage and abortion observed Bud and stem deformation occurs due to larval attack Pod damage results in secondary rotting (Alomia 1974)

Biology

The females are active at night About 4 days after copulation starts oviposition averaging 110 eggs per female deposited in 4 8 eggmasses over a period of 1 2 weeks Eggs are laid on young plant tissue Adults live 15 22 days The eggstage lasts 3 8 and 6 8 days in summer and winter respectively and in these corresponding seasons the 5 larval stages are passed in 14 and 23 days The pupation takes place in a cocoon on the leaves or the ground (Wille 1943)

Control

Wille (1943) encountered a Tachinid larval parasite (*Eucelatoria australis*) which pupates in the host pupal skin Avalos (pers comm) tested almost 200 varieties for resistance to Epinotia and encountered large differences in percentage of terminal buds and pods attacked Chemical control is best obtained with Aminocarb Torbidan on Omethoate (Torres 1968) In Chile (C Quiroz pers comm) early planting in spring reduced percentage of pods damaged by Epinotia to 4 3/ as compared with 72 3/ in late spring plantings

Laspeyresia leguminis Heinrich (Lepidoptera Olethreutidae)

Laspeyresia leguminis is a pest in beans in South America (Wille 1943 and ALAE 1968) Its damage is often confounded with that of Epinotia It also attacks other legumes like soya broadbeans and Limabeans

Damage is similar to that of Epinotia but it may also webs pods together not done by Epinotia (Avalos pers comm) Adults oviposit on pods and the young larvae bore into them destroying the seeds The larva pupates in the pod (Wille 1943) Control is similar to that of Epinotia

Maruca testulalis (Geyer) (Lepidoptera Pyralidae)

Like most of the other podborers M testulalis oviposits near or on flower buds and on young leaves and flower and young pod damage occur prior to podboring type feeding (Scott 1940) It also attacks several species of legumes among others beans Leonard (1931) lists distribution and hosts

M testulalis is distinguished from Etiella zinckenella the lima bean pod borer by larval and adult coloring Maruca larvae have 4 black or dark grey spots on each segment while its adults rests with wings spread Larvae of M testulalis expulse frass from the pods while E zinckenella leaves it in the pod (Stone 1965) Maruca testulalis is reported from

Brazil (Ruppel and Idrobo 1962) Colombia (Posada et al 1970) and Cuba and Puerto Rico (Leonard 1931)

3 *Heliothis* sp

Damage by the *Heliothis* complex (*H zea* and *H virescens*) is sporadic but can be severe The adult oviposits on the young leaves and larvae feed on the seeds perforating the podwalls above the seed Several seeds per pod may be destroyed and secondary rotting can cause the loss of the remaining seeds It is not clear which of the two species mentioned is the most common in beans however during a recent attack we found *virescens* only

Chemical control of older larvae is difficult however high levels of parasitism usually occur Posada (1976) lists of *Heliothis* sp 26 different parasite or predator species from Colombia During a recent attack we observed 89 2/ of the field collected larvae parasitized by a Tachinid fly

Stored beans attacking insects

The principal pest of stored beans are two Bruchids *Acanthoscelides obtectus* (Say) (Synonyms are *Mylabris obtectus* and *Bruchus obtectus*) and *Zabrotes subfasciatus* (Boheman) (Synonyms are *Z pectoralis Z dorsopictus* and *Spermatophagus subfasciatus*) Both pests are widely distributed being reported from Chile on northward to the United States We found 28 other insects reported on stored beans They are of minor importance or accidntally found on beans These have no economic importance as far as literature reports and from our own observations In the next part of this paper only the first two mentioned species are considered

Biology of the important pests

The life history of the two most important bean pests A obtectus and Z subfasciatus is broadly similar and is studied in detail by Howe and Currie (1964) The main difference is in oviposition behavior A obtectus females scatter eggs among stored seeds or infest beans in the field They lay their eggs in cracks or cuts o the growing pods The newly hatched larvae of A obtectus penetrate the seed In contrast Z subfasciatus eggs are firmly attached to the seed On hatching the young larvae bore through the eggshell and seedcoat in one process (Howe and Currie 1964)

Larvae of both species molt 4 times before pupating During the last larval instar the feeding and pupation cell becomes externally visible as a circular window in the seed as the larvae feed on the lower surface of the testa After pupation the adult may remain in the cell for several days before pushing out the window It has ability to escape by eating away the exit Adults do not eat but will take water or nectar Oviposition starts rapidly after emergence and adults are short lived (Howe and Currie 1964)

The optimum conditions for rapid development of A obtectus eggs were 70/ RH and 30°C when the insects spent 22 5 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 11 8 days at 30°C and 70/ RH Under these conditions a female lays an average of 63 0 eggs (Howe and Currie 1964)

For Z subfasciatus the optimum developmental period including the egg stage is about 25 0 days at 707 RH and 32 5°C In this species 7 2 percent of adults were unable to escape from the pupal cell and died

Zabrotes adults exhibit large sexual dimorphism The female usually weighs 1 1 ? x the mal Adults live 7 6 days at 30°C and 70/ RH At these conditions a female lays average 35 5 eggs (Howe and Currie 1964)

In our observations Acanthoscelides obtectus is distributed over the higher latitudes and altitudes while Zabrotes subfasciatus found predominantly in the warmer areas Copetition between the two species does exist In studies by Giles in Nicaragua (Giles pers comm) at 56 m 450 m or 680 m above sea level beans were initially infested with A obtectus (9? 7/) and Z subfasciatus (0 3/) After 16 weeks the rations were 0 100/ a 56 m 4 6 95 47 at 450 m and 27 3 76 6/ at 680 m The average temperatures at these three elevations were 28 2°C 25 2°C and 24 3°C respectively This indicates that A obtectus is a stronger competitor at lower temperatures

No precise information was found in the literature about economic losses caused by insects in stored beans McGuire and Crandall (1967) estimate that for Mexico Central America and Panamá storage losses are as high as 35 percent They do not specify if these losses are from insects or other causes

In a marketing survey in Brazil (Recife area) average storage and handling losses further unspecified during the market process amounted to 13 3/ (Slater et al 1969)

In a survey we made on farms in the bean growing areas and 30 warehouses in Colombia we concluded that the average storage period is very short during which an estimated loss of 7 4/ is suffered(Schoonhoven 1976)

Farmer and non chemical control measures

Local farm practices to control weevils i applying ashes from fireplaces to the stored beans for future planting The value of this method as a physical barrier for the weevils appeared to be effective (CIAT 1975)

Storing beans in undamaged pods is a safe control measure against Zabrotes attack Eggs deposited on the podwalls hatched and larvae penetrated the podwalls but died inside the pods without penetrating the seed Although effective for Zabrotes this method should not be used to control Acanthoscelides as this insect is able to attack beans in the pods Labeyrie (1957) showed that storing beans unshelled or delaying the harvest greatly enhances Acanthoscelides attack

Another non chemical method for controlling weevils is the use of black pepper One gram of ground pepper per 385 g beans reduced infestations of A obtectus by 78/ after 4 months storage compared with untreated lots At 4 26 g per 385 g the reduction was 97 9/ (Lathrop and Keirstead 1946)

Inert dusts especially crystalline silica bentonite and magnesium carbonate were effective in killing A obtectus especially the fraction of fine particles is most effective The killing of adults (50/ killed in 12 hrs by bentonite) was ascribed to water loss (Chiu 1939)

In our laboratory we tested about 700 entries of P vulgaris for resistance to Z subfasciatus Several entries rated very resistant bwt some were classified susceptible when tested in the next generation Seed should maintain its resistance for at least 3 generations of test ing before it can be called resistant andused for further studies Resistance to Acanthoscelides has also been reported (e g Lefebre 1950)

Chemical control methods

Chemical control of weevils is readily obtained with a variety of products

Pyrethrins are highly effective in controlling stored grain insects Salas and Ruppel 1959 McFarlane 1970

In our studies on Z subfasciatus pyrethrins on bases of marc gave long lasting control and provided an appearance to the beans mostly red mottled much more acceptable than pyrethrins with talc as carrier Synthetic pyrethrins tested also gave excellent control

In our survey most warehouses used few products to control storage insects A total of 33 3/ of the warehouse owners used fostoxin 40/ used methyl bromide 26 77 used CS_2 and 134 used pyrethrin One store owner confessed he used aldrin to control bruchids

Future research

The main obligation in our work is to reduce losses from insects in beans Therefore a suggested outline for future research and control strategies in Latin America includes largely our own research program

It is hard to accept heavy losses from insects and prevent them by pesticides when varieties are available carrying genetic resistance to these pests lik to Empoasca kraemeri Apion godmani Epilachna varivestis Epinotia opposit etc Our main objective is to incorporate resistance into commercial varieties for key pests for which resistance sources are readily available A breeding program has been started to incorpora te these resistances into materials with resistance to diseases (mostly Common Bean Mosaic Virus and Rust) A retarding factor is the strong seed color preference different per country which we have to obey

While the process of development of varietal resistance is time consuming most national programs are improving their chemical control recommendations e g recent studies on systemic granular insecticides like furadan or thimet greatly reduces bean golden mosaic incidence This is a much safer recommendation than repeated foliar sprays from an integrated pest control approach Several bean programs still recom mend chlorinated hydrocarbons

More emphasis towards a pest management system is necessary Bio logical control is an essential part of this Admittedly the short growing season of beans and the periods of fallow reduce the possibili ties of biological control However with a reduced pesticidal need to control key pests like Empoasca and Apion by the potential use of resist ant varieties other pests like the lepidopterous leaffeeders may increasing ly be controlled biologically They have several hosts and therefore a more stable population level Search for and releases of more efficient natural enemies may however be out of reach for most national programs due to lack of funds and trained personnel

Cultural control should play a large role in a pest management system The shifting of planting dates may be a very powerful tool to control insects however it is of limited value in Latin America where the rainfall distribution is the principal factor governing planting date For *Empoasca* control it is favorable that the beginning of the rainy season goes with a reduction in leafhopper populations and their damage For *Hylemya* a late planting date and plowing some days before planting may be of great use It must be said however that the biology and eco logy of most pests is not sufficiently studied for firm recommendations

As discussed before the distribution of the principal bean insects varies greatly within Latin America Proper quarantaine measures should continue to be enforced not to widen the distribution of these pests

Probably the most important aspect of crop pest management is the elimination of nnecessary insecticidal sprays This means the need for a better and more accurate knowledge of the relationship between insect pest populations and the to be expected yield reduction Most entomolo gists involved with bean research expect that a certain amount of damage can be done before yield reduction starts to occur Our research with *Empoasca* seems to indicate that the first insects allowed on a plant do more damage than those additionally permitted This indicates that the decision to spray is not only based on expected yieldloss but more on the cost of the insecticidal spray and the consequences of this spray on later pest development especially those of lepidopterous insects and their natural enemies The curve of population level versus damage for *Empoasca* seems different from those of foliage feeders where indeed part of the foliage can be removed before yieldloss starts to show up

References

ALAE 1968 Asoc Latinoamer de Entomol Catalogo de insectos de importancia economica en Colombia Public No 1 pp 156

Alomia B E 1974 (?) El *Epinotia opposita* Heinr (Lepidoptera Olethreutidae) plaga del frijol en Antioquia ICA Medellín pp 5

Alonzo F 1975 Estudios en *Phaseolus vulgaris* L sobre el control de la mosca blanca *Bemisia tabaci* (Genn) en la zona sur-oriental de Guatemala Paper presented at workshop on bean plant protection CIAT Dec 1 3 1975 pp 18

Augustine M G F W Fisk R H 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

Beyer A H 1922 The bean leafhopper and hopperburn with methods of control Florida Agric Expt Sta Bull 164 61 88

Bonnefil L 1965 Las plagas del frijol en Centro America y su combate En XI Reunion del PCCMCA Panamá Marzo 17 19 95 103

Cadena, D and J A Sifuentes 1969 Prueba comparativa de la efectividad de 4 insecticidas para combatir la conchuela del frijol (*Epilachna varivestis*) bajo condiciones de campo Agric Tecn en Mexico 2 (10) 440-444

Campbell W V and C H Brett 1966 Varietal Resistance of beans to the Mexican Bean Beetle J Econ Entomol 59(4) 899-902

Campos J 1972 Insecticidas impregnados a la semilla del maiz para el control de *Elasmopalpus lignosellus* (Zeller) (Lepidoptera Pyralidae) Rev Peruana de Entomol 15 (2) 348 351

Associated cropping a system in which an estimated 80% of the beans in Latin America are grown needs more attention It is possible that abandoning this system may reduce the stability of the ecosystem and increase certain insect pests

Finally excellent work has been done by Latin American entomologists However lack of funds often inhibit publication of their work so that others can profit from their knowledge and experience We believe that this has hindered a more rapid progress in bean entomological research

Chalfant R B 1965 Resistance of Bunch Bean Varieties to the Potato Leafhopper and Relationship Between Resistance and chemical control J Econ Entomol 58 681 682

Chiu S F 1929 Toxicity studies of so called inert materials with the bean weevil Acanthoscelides obtectus (Say) J Econ Entomol 32 (2) 240 248

CIAT Centro Intern de Agric Trop Annual Reports 1973 1975

Costa D S 1970 Acaros inimigos invisiveis do algodoeiro Dilvulgacao Agron 29 6 9

Costa C L and C J Rossetto 1972 Investigacoes sobre pragas do feijoeiro no Brasil En Anais do 1 simposio Brasileiro de feijao Campinas 22 29 Aug 1971 2a Vol Impr Univ Viscosa M G Brasil

Cromroy H L 1958 A preliminary survey of the plant mites of Puerto Rico J of Agric of the Univ of Puerto Rico 42 39 144

De la Paz S R Reyna and A Martinez El rendimiento de frijol en funcion del grado de daño de la conchuela (Epilachna varivestis Muls) In press

Doreste E 1968 Primera lista de acaros de importancia agricola en Venezuela Agron Trop (Venezuela) 18 452

Dupree M 1965 Observations of the life history of the lesser con stalk borer J Econ Entomol 58 (6) 1156 1157

Eckenrode C J N L Gauthier D Danielson and D R Webb 1973 Seedcorn maggot Seed treatments and granule furrow applications for protecting beans and sweet corn J Econ Entomol 66 (5) 1191 1194

Enkerling D 1951 El picudo del ejote Apion godmani Wagn su importancia economica y experimentos para su control en el estado de Michoacan Mexico Secretaria de Agric y Ganadería Folleta Misc 4 126 130

Flechtman C H W 1972 Acaros de Importancia Agricola Sao Paulo Nobel pp 150

Fluiter H J de and G W Ankersmit 1948 Gegevens betreffende de aantasting van bonen (P vulgaris) door de zwarte Bonenluis (Aphis (Doralis) fabae Scop) Tijdschrift over plantenziekten 54 1 13

Gamez R 1972 Los virus del frijol en Centroamerica II Algunas propiedades y transmision por crisomelidos del virus del mosaico rugoso del frijol Turrialba 22 249 257

Garcia C 1971 Control del pegador de hojas y de la mosca de los brotes del pallar (Investigación de control químico) Min de Agric y Pesqueria Boletin de Menestras 19 pp 5

Garcia C and C Sosa 1973 Evaluacion de la resistencia de frijol hacia la conchuela Epilachna varivestis Muls (Coleoptera Coccinellidae) Agrociencia Serie D 10 3 13

García F 1975 Plagas de la soya En El cultivo de la soya en Colombia Inst Colombiano Agric (ICA) Compendio 6 pp 56

Gates D 1945 Bean insect control In Nebraska Agric Expt Sta Ann Rept 58 61

Gonzales P M 1969 Resultados del control químico de la arañita roja (Tetranychus sp) en frijol en el valle de Camara Arequipa Rev Peruana de Entomol 12 58 70

Green C L 1971 a Economic Damage Levels of bean leaf roller populations on Snap beans J Econ Entomol 64(3) 673 674

Green C L 1971 b Instar di tributions natural populations and biol gy of the bean leaf roller Florida Entomol 54(3) 213 219

Green G L and D R Minnick 1967 Snap bean yields following simulated insect defoliation Proceedings Florida State Hort Soc 80 132 134

/Guevara J 1957 El desarrollo y uso de variedades de frijol resistentes a ciertas plagas de las leguminosas Sobretiro de la Revista Chapingo Nos 62 63 64 65 y 66 pp 61

Guevara J 1962 El combate del picudo del ejote mediante la combinacion de variedades resistentes e insecticidas Agric Tecn en Mexico 2 17 19

Guevara J 1969 Resistencia a insectos In O Brauer Fitogenetica aplicada Edit Lenusa Wiley S A Mex pp 518

Gutierrez U M Infante and A Pinchinat 1975 Situacion del cultivo de frijol en America Latina Centro Int de Acric Trop (CIAT) Serie ES 19 pp 33

Hagen A F 1974 Mexican Bean Beetle Control with Systemic Insecticides on Dry Beans in Western Nebraska J Econ Entomol 67 137

Hambleton E J 1938 A ocorrencia do acaro tropical Tarsonemus latus Banks (car Tarsonemidae) causador da rasgadura das folhas nos algodoais de S Paulo Arquivos do Inst Biologico 9 201 209

Harris C R H J Svec and J A Begg 1966 Mass rearing of root maggots under cont lled invironmental conditions Seedcorn

Maggot *Hylemya cilicrura* bean seed fly *H liturata* *Euxesta notata* and *Chaetopsis* sp J Econ Entomol 59 (2) 407 410

Harris K M 1969 Population increase of *Stenotarsonemus pallidus* (Banks) following spray applications of dimetoate Plant Path 18 113 115

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(4) 491-497

Hertveldt L and G Vulsteke 1972 Biology and Control of the bean fly *Hylemya cilicrura* Rond Mededelingen van de Faculteit Landbouwwetenschappen Ryksuniversiteit Gent 37(1) 139-153

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(3) 437 477

Infante M A C M Scobie and U Gutierrez 1974 Producción y consumo de frijol seco y su contribucion a la oferta de proteina a nivel mundial Paper presented in XX Reunión anual del PCCMCA San Pedro de Sula Honduras 11 14 Feb 1974 pp 47

Kapoor K N J P Gujrati and G A Gangrade 1972 Bionomics of *Lamprosema indicata* Fabracius a pest of soybeans in Madhya Pradesh Indian J Entomol 34 102 105

Lebeyrie V 1957 Influence des technique de recoltes des haricots secs l intensite des attaques de la Bruche (Acanthoscelides obtectus Say) Conte Rendu Acad Agric 43 (3) 138 140

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 Agric and Food Chem 11 (6) 462 463

Lathrop F H and L G Keirstead 1946 Black pepper to control the bean weevil J Econ Entomol 39 (4) 534

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

Lenis G and D Arias 1976 Contribucion al conocimiento de Hedylepta indicata Fabricius (Lepidoptera Pyralidae) y de sus más frecuentes enemigos naturales Tesis Univ Nac Fac de Agron pp 46

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

Leuck D B and M Dupree 1965 Parasites of the lesser corn stalk borer J Econ Entomol 58 (4) 779 780

Leuck D B 1966 Biology of the lesser cornstalk borer in South Georgia J Econ Entomol 59 (4) 797 801

Mancía J E M R Cortez and O Gracias 1973 a Efectividad de varios insecticidas en el combate del picudo de la vaina del frijol comun Apion godmani Wagn 1971 1972 El Salvador SIADES 2 2 14

Mancia J E A de Jesus Díaz and O Gracias M 1973 b Utilizacion de insecticidas sistemicos granulados en el control de mosca blanca Bemisia tabaci Genn e infeccion virosa en frijol En XIX Reunion Anual del PCCMCA San José Costa Rica 5 8 Marzo 1973 pp 9

Mancia J E 1973 a Evaluacion de variedades de frijol tolerante al picudo de la vaina Apion godmani Wagn SIADES 2 15 20

Mancia J E 1973 b La biología del picudo de la vaina del frijol Apion godmani Wagn y su distribucion en el Salvador SIADES 2 (2) 12 29

Mancia J E and M Román C 1973 Biología de la conchuela del frijol comun Epilachna varivestis Muls In XIX Reunion Anual del PCCMCA San José Costa Rica 5 8 Marzo 1973 10 p

Mancia J E O Gracias and M Cortes 1974 Determinacion de la mejor epoca de control el picudo de la vaina del frijol comun Apion godmani Wagn SIADES 31 59 66

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

McFarlane 1970 Control of the bean bruchid Acanthoscelides obtectus (Say) by synergised pyrethrins powders Pyrethrin Post 10 34 40

McGuire J U and B S Crandall 1967 Survey of insect pests and plant diseases of selected food crops of Mexico Central America and Panamá Int Agric Dev Serv Agric Res Serv USDA AID Oct 1967 pp 157

McKelvey J J J Guevara and A Cortes 1947 Apion pod weevil A pest of beans in Mexico J Econ Entomol 40 476-479

McKelvey J J A C Smith J Guevara and A Cortés 1951 Biología y control de los picudos del género Apion que atacan al frijol en Mexico Secretaría de Agric y Ganadería Folleto Tecn 8 7 42

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

McLeod D G R 1965 Are Hylemya cilicrura and H liturata two separate species? Proc Entomol Soc Ontario 95 140 142

Medina R and I Guerra 1973 Evaluacion del comportamiento genético de frijol infestado en forma natural con chicharrita (Empoasca fabae Harris) picudo Apion godmani (Wagner) y conchuela del frijol Epilachna varivestis en Calera Zac CIANE 13 p

Metcalf G L and W P Flint 1972 Insectos destructivos e insectos utiles Sus costumbres y su control Co Edit Cont S A Mexico pp 1208

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 The Canadian Entomologist 92 (3) 210 221

Miranda C 1967 Fechas de siembra e incidencia de Empoasca spp en frijol XIII Reunion PCCMCA San José Costa Rica Febrero 28 Marzo 4 1967

Miranda S 1971 Efecto de las malezas plagas y fertilizantes en la produccion de frijol Agric Tecn en Mexico 3 (2) 61 66

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

Nickel J L 1960 Temperature and humidity relationships of *Tetranychus desertorum* Banks with special reference to distribution Hilgardia 30 (2) 41 100

Piedrahita J 1974 Biología de *Tetranychus desertorum* Banks (Acarina Tetranychidae) y pruebas de resistencia de 7 variedades de fríjol (*P vulgaris*) a su ataque Thesis Univ Nac Fac Agron Palmira pp 40

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

Pitre H N and E J Kantack 1962 Biology of the Banded Cucumber Beetle *Diabrotica balteata* in Louisiana J Econ Entomol 55(6) 904 906

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 Agric ICA Public Misc 17 pp 202

Posada L and F García 1976 Lista de predatores parásitos y pato genos de insectos registrados en Colombia Min de Agric ICA Boletín Tecn 41 pp 90

Pulido J I and C Lopez 1973 Biología y algunas plantas hospedantes del cucarroncito de las hojas *Diabrotica balteata* LeConte (Coleoptera Chrysomelidae) Tesis Fac Agric Univ Nac pp 50

Quaintance A L 1898 Three injurious insects bean leafroller corn delphax Canna leafroller Florida Agric Expt Sta Bull 45 53 74

Ramírez M E Casas y A Rubio 1959 Susceptibilidad de algunas variedades de fríjol al picudo del ejote en la Mesa Central Agric Tecnica en Mexico 7 6 38

Rodas H R 1973 Porcentaje de parasitismo morfología longevidad y posibilidad de cria de algunos dipteros parásitos de larvas de *Estigmene acrea columbiana* (Rothschild) (Lepidoptera Arctiidae) en el Valle del Cauca Thesis Univ Nac Agron Palmira 1973 pp 47

Ross H H and T E Moore 1957 New species in the *Empoasca fabae* complex (Hemiptera Cicadellidae) Ann Entomol Soc Amer 50 118 121

Ruppel R F and D M DeLong 1956 *Empoasca* (Homoptera Cicadellidae) from highland crops of Colombia Bull Brooklyn Entomol Soc 51 (4) 85 92

Ruppel R F and E Idrobo 1962 Lista preliminar de insectos y otros animales que dañan fríjoles en America Agricultura Tropical 18(11) 651 679

Russel L M 1975 Whiteflies on beans in the western hemisphere Paper presented at workshop on bean plant protection CIAT Dec 1 3 1975 pp 21

Salas L and R F Ruppel 1959 Efectividad de insecticidas aplica dos en polvo para controlar las principales plagas del fri jol y del maiz almacenados en Colombia Agric Trop (Colombia) 15 (2) 93 108

Schoonhoven A van 1976 Pests of stored beans and their economic importance in Latin América Paper presented at 15th Intern Congress Entomol Symp Tropical Stored Prod Entomol Aug 19 27 Washington D C 1976 pp 26

Scott L B 1940 The bean pod borers in Puerto Rico J Agric Univ Puerto Rico 24 35 47

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 the Recife area of Northeast Brazil Rept 2 Latin America Studies Centre Michigan St Univ

Smiley R L 1974 A new species of Coccipolipus Parasitic on the Mexican Bean Beetle (Acarina Podapolipidae) Wash Aca Sci 64(4) 298 302

Stevenson W A W Kaufman and L W Sheets 1957 The Salt Marsh Caterpillar and its control in Arizona J Econ Entomo 50 279 280

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 longe and host parasite ratios Environm Entomol 4(6) 953 957

Stone M W 1965 Biology and control of the Lima bean pod borer in Southern California USDA Techn Bull 1321 pp 46

Thomas F L 1924 Life history and control of the Mexican Bean Beetle Ala Agric Expt Sta Bull 221 pp 99

Tissot A N 1932 Studies on the bean Jassid In Florida Agric Expt Sta Ann Rept 1932 73 74

Torres N 1968 Un control químico de Epinotia sp en fríjol Rev Peruana de Entomol 11(1) 77 79

Turner N 1932 The Mexican bean beetle in Connecticut y J Econ Entomol 25 617 620

Turner N 1935 Effect of Mexican Bean Beetle injury on crop yield J Econ Entomol 28 147 149

Turnipseed S G and M Kogan 1976 Soybean entomology Ann Rev Entomol 21 247 282

Vea E V and C J Eckenrode 1976 Resistance to seedcorn maggot in snap bean Evironmental Entomol 5 735 737

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

Wilde G A van Schoonhoven and L Gomez Laverde 1976 The biology of Impoasca kraemeri on Phaseolus vulgaris Ann Entomol Soc of America 69(3) 442 444

Wilde G and A van Schoonhoven 1976 Mechanisms of resistance to Empoasca kraemeri in Phaseolus vulgaris Environm Entomol

5(2) 251 255

Wille J E 1943 Entomología Agrícola del Perú Min de Agric Lima Peru pp 466

Wolfenbarger D and J P Sleesman 1961 a Resistance in Common Bean Lines to the Potato Leafhopper J Econ Entomol 54(5) 846 849

Wilfenbarger D And J P Sleesman 1961 b Plant Characteristics of _Phaseolus vulgaris_ Associated with Potato Leafhopper Nymphal Infestation J Econ Entomol 54(705 707)

Wilfenbarger D and J P Sleesman 1961 c 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

Wolfenbarger D and J P Sleesman 1961 d Resistance to the Mexi can bean Beetle in Several Bean Genera and Species J Econ Entomol 54(5) 1018 1022

Young W R and J A Sifuentes 1959 Biological and control studies on _Fstigmene acrea_ (Drury) a pest of corn in the Yaqui Valley Sonora Mex J Econ Entomol 52 1109 1111

Young W R 1959 1960 Banded Cucumber Beetle Biological and ecolo gical studies In Annual Rept Rockefeller Found Agric Sciences 1959 1960 pp 73 74

Young W R and D Candia 1962 Biología y control de la doradilla en el campo Cotaxtla Ver Agric Tecn en Mexic 2(3) 33 38

Zaumeyer W J and H R Thomas 1957 A Monographic study of bean diseases and methods for their control USDA Techn Bull 868 pp 255

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