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PULSE CROPS OF THE WORLD AND THEIR  
IMPORTANT INSECT PESTS

by

Carl Edmond Joplin  
B.A., Antioch College, 1973

A PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF  
THE REQUIREMENTS FOR THE DEGREE OF  
MASTER OF PEST MANAGEMENT  
in the Department  
of  
Biological Sciences

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Simon Fraser University

December, 1974

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14 January 1975

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## ABSTRACT

Pulse crops (grain legumes) are an increasingly important source of protein for a majority of the world's people. This paper provides background information and selected references that a pest manager would find useful when working with an unfamiliar cropping system of pulses and their insect pests.

The first chapter summarizes agronomic, economic, and nutritional data on 14 major species of pulses. References are provided to sources of information on these and 15 other important species.

The second chapter identifies the insect genera and species that are important pests of pulses. Approximately 220 species of insects and related arthropods are catalogued indicating common name, commonly damaged pulse crop hosts, and selected references. Three species that are representative of common types of pest problems are described more thoroughly in terms of their biology, ecology, and control. These are Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae), Heliothis armigera (Hubner) (Lepidoptera: Noctuidae), and Ophiomyia (= Melanagromyza) phaseoli (Tryon) (Diptera: Agromyzidae).

The concluding chapter discusses the status and possibilities of pest management on pulse crops and provides information on several internationally important institutions that are conducting such work.

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## INTRODUCTION

The function of this paper is to provide quick access to information on the major pulse crops and their most important insect pests such as might be needed by a pest manager faced with a new crop or pest. References to the literature were therefore selected to emphasize the type of information that is necessary background for the development of a basic pest control program. Such generalized information would be a starting point for a person needing a thorough understanding of a host-pest situation.

A pest manager needs to be familiar with the host as well as the pest. To this end, 14 species of major pulse crops are described in terms of their uses, culture, and level of cultivar development. Other less important pulse species are listed giving synonymy, common names, and selected references.

Approximately 220 insects were found to be often economically damaging pests of pulses. References to literature illuminating the biology, ecology, and control of these insects is provided.

Because of the possible magnitude of this project, three pests representative of widespread and damaging groups of insects were selected for more detailed review. These reviews are examples of concise descriptions of insect pests that should be available to persons involved in local, in-the-field control programs. As control personnel are upgraded by legislated regulations and a growing professionalism, a need is apparent

for information bridging the gap between the simple pamphlet available to the farmer and the technical research report. The data gathering for this paper took advantage of applied entomology manuals that are available for many parts of the world. They are often the most complete and accessible sources of information on specific species. They are also often more available to the man in the field than scattered journal papers. For the three reviews of representative pest species, searches were also undertaken of the scientific literature.

A chronic problem when dealing with crops and pests on a worldwide basis is a lack of knowledge, or lack of attainable published knowledge, on the organisms involved. Particularly when working on tropical crops, the dearth of basic research on many agro-ecosystems results in this type of project being incomplete. Much of the problem is due to language barriers and to publications with limited circulation outside their home region. An example of this is Latin America, a region highly dependent on pulses, which publishes mostly in Spanish and Portuguese, often in hard-to-get proceedings of annual meetings and conferences. Information of this type from China and the USSR is also difficult to obtain. In contrast, English-language books are available on crop pests of many of the countries that have a British colonial history.

The work done in developed countries has purposely not been over-emphasized in this paper. The sheer mass of literature produced concerning crops such as soybeans in the United States indicates a high level of specialization and

sophistication. Such information is useful and probably trend-setting, but it is not necessarily even potentially feasible for much of the world to produce food by the industrialized manner by which it is grown in North America.

Compared with some other crops, pulses have until recently been relegated to a secondary position in the "green revolution". Pest control has played an important role in the attempt by internationally-sponsored research on the "miracle grains" to keep food production increases at a rate approximating that of population growth. However, the potential of pulses to produce a larger percentage of the world's protein needs than they presently do is only currently being exploited. The last chapter of this paper examines several major attempts to improve pulse production, particularly with respect to pest control.

## I. PULSE CROPS

### 1. SPECIES OF PULSE CROPS OF ECONOMIC IMPORTANCE

#### a) Definitions and Criteria for Selection

The legume family of plants is second in importance to mankind only to the grains of the grass family, upon which a majority of the world's population depend for their staple energy source. The high protein value of legumes makes them of great importance to a world already experiencing massive protein-calorie malnutrition, with even greater food deficits on the horizon. The relatively high protein composition of legumes, even when not heavily fertilized, may be in large measure due to their ability to symbiotically fix atmospheric nitrogen into a form that can be utilized in the synthesis of amino acids and therefore proteins.

Legumes are utilized by humans either by direct consumption of the pod and seed or secondarily through feeding to livestock. Forage legumes such as alfalfa (lucerne) and clover are generally unpalatable to humans, but are an indispensable source of nutrients for domestic animals. However, many legume species, especially after centuries of selection, produce a seed large and wholesome enough to be eaten by humans. It is this seed that is called a pulse.

Webster's Third New International Dictionary (1966) defines "pulse" as "the edible seeds of various leguminous crops (such

as peas and beans)" or "a plant yielding pulse". The word itself is probably derived from the Greek poltos or the Latin puls, meaning porridge. The term is synonymous with "edible legumes" or "peas, beans, and lentils", which is the common terminology in the Americas. The term "grain legumes" is sometimes advocated when specifically referring to crops whose seeds are harvested in a dry or mature state. This differentiation is necessary because many legume species have cultivars that have been selected to produce a succulent young seed or pod that is eaten as a vegetable, such as the string bean and garden pea. Although these garden cultivars are important sources of vitamins and other nutrients, their bulk and short shelf-life generally make them impractical as major protein sources. These "vegetable" legumes are usually affected by the same pests that damage dry seed production and so most of their insect pests are to be found in this paper.

The plants which are considered in this paper were selected on the basis of meeting three requirements. First, they must be taxonomically classified as members of the botanical family Leguminosae (=Leguminosaceae, Leguminales), subfamily Papilionoideae (=Faboidae, Papilionatae, Fabaceae, Papilionaceae). Although several "beans" from tropical leguminous trees of the subfamily Mimosoideae are locally eaten, they are of no great agricultural importance.

Secondly, the plants listed here are species whose seeds and sometimes pods are consumed by humans as a source of

nourishment. Not included are those plants whose sole economic importance is as a cover crop, green manure, animal feed or forage, or as a source of condiment, drug, insecticide, or other biochemical.

The third criterion is more difficult to apply due to its subjective nature. It was found necessary to limit the pulse species considered here to those that are of significant economic importance on at least a continental scale. The research for this review revealed over 95 species of legumes eaten by man. Only about a third of these are a major portion of the diet of any nation. To keep this project within reasonable limits, it was necessary to concentrate on 29 species that are of enough importance that they might justify the presence of a pest manager. Of these, 14 species are considered "major" pulses.

b) List of 29 Species of Important Pulse Crops (Including  
Synonymy, Common Names, and Selected References)

\* = Covered more fully in section 2 - Major  
Pulse Crops of the World

\* Arachis hypogaea L.

peanut, groundnut, goober, earth nut, earth almond,  
monkeynut, grass nut, Manilla nut

\* Cajanus cajan (L.) Millsp.

[=C. indicus Spreng.]

pigeon pea, Congo pea, Angola pea,  
no-eye pea, red gram, alberga

Canavalia ensiformis (L.) DC.

jack bean, horse bean, overlook bean,  
Chickasaw lima bean

References: Aykroyd and Doughty 1966 p.12; Harrison et al.  
1969 p.40; Herklots 1972 p.233; Purseglove 1968 p.242;  
Whyte et al. 1953 p.258.

\* Cicer arietinum L.

gram, chick pea, garbanzo bean, Indian gram,  
Egyptian pea, Idaho pea, ceci bean



Dolichos uniflorus Lam.[=D. biflorus auct. non. Linn.]

horsegram, kulthi bean

References: Aykroyd and Doughty 1966 p.14; Commonwealth  
Bureau of Pastures and Field Crops [date unknown]d;  
Purseglove 1968 p.263; Whyte et al. 1953 p.272.

\* Glycine max (L.) Merr.[=G. soja (L.) Sieb. and Zucc.; Soja max (L.) Piper]

soy bean, soya bean

Kerstingiella geocarpa Harms.[=Voandzeia poissoni Chev.]

Kersting's groundnut, ground bean, geocarpa

References: Aykroyd and Doughty 1966 p.15; Purseglove  
1968 p.329; Uphof 1968 p.548.

\* Lablab niger Medik[=Dolichos lablab L.; L. vulgaris Savi.]

hyacinth bean, lablab bean, waby bean, bonavist bean,  
Indian bean, dolichos bean, Australian pea, papaya bean,  
Egyptian kidney bean

Lathyrus ochrus DC.

ochrus, ochrous pea, louvana

References: Aykroyd and Doughty 1966 p.15;  
Hedrick 1919 p.328.

Lathyrus sativus L.

grass pea, chickling pea, grass peavine, chickling vetch

References: Aykroyd and Doughty 1966 p.15; Purseglove  
1968 p.278; Hedrick 1919 p.328

\* Lens esculenta Moench.

[=L. culinaris Medik.; Ervum lens L.]

lentil )

Lupinus albus L.

[=L. sativus Gaertn.]

white lupine, field lupine, wolf-bean

References: Aykroyd and Doughty 1966 p.16; Hedrick  
1919 p.341; Uphof 1968 p.32

Lupinus termis Forsk

Egyptian lupine

References: Aykroyd and Doughty 1966 p.17; Hedrick  
1919 p.342; Uphof 1968 p.32.

Phaseolus aconitifolius Jacq.

[=P. trilobus Ait.]

moth bean, mat bean, dew gram, Turkish gram, aconite-  
leaved kidney bean, phillipesara

References: Aykroyd and Doughty 1966 p.18; Commonwealth  
Bureau of Pastures and Field Crops [date unknown]j;  
Hedrick 1919 p.418; Herklots 1972 p.244;

Purseglove 1968 p. 287; Uphof 1968 p.399;

Whyte et al. 1953 p.33.

Phaseolus acutifolius Gray var. latifolius Freem.

teparty bean, Texas bean, dinawa

References: Aykroyd and Doughty 1966 p.18; Commonwealth

Bureau of Pastures and Field Crops [date unknown]j;

Herklots 1972 p.245; Purseglove 1968 p.287;

Whyte et al. 1953 p.33.

Phaseolus angularis (Willd.) Wight

adzuki bean, adanka bean

References: Aykroyd and Doughty 1966 p.18; Commonwealth

Bureau of Pastures and Field Crops [date unknown]j;

Purseglove 1968 p.289; Whyte et al. 1953 p.33.

\* Phaseolus aureus Roxb.

[=Vigna aureus (Roxb.) Hepper]

mung bean, mungo bean, green gram, golden gram, mash

bean, Chinese bean sprouts, Tientsin green bean,

Oregon pea, chickasano pea

Phaseolus calcaratus Roxb.

rice bean, red bean

References: Aykroyd and Doughty 1966 p.18; Commonwealth

Bureau of Pastures and Field Crops [date unknown]j;

Harrison et al. 1969 p.36; Herklots 1972 p.247;

Purseglove 1968 p.294; Whyte et al. 1953 p.34.

Phaseolus coccineus L.

[=P. multiflorus Willd.]

scarlet runner bean, white Dutch runner bean, multiflora bean, astec bean, Oregon lima bean

References: Aykroyd and Doughty 1966 p.19; Commonwealth Bureau of Pastures and Field Crops [date unknown]j;  
Herklots 1972 p.248; Purseglove 1968 p.295.

\* Phaseolus lunatus L.

[=P. limensis Macf.; P. inamoenus L.]

lima bean, sieva bean, butter bean, sugar bean, Burma bean, Madagascar bean, Java bean, Rangoon bean, civet bean, guffin bean

\* Phaseolus mungo L.

[=Vigna mungo (L.) Hepper]

black gram, urd bean, wooly pyrol

\* Phaseolus vulgaris L.

common bean, kidney bean, navy bean, pinto bean, haricot bean, snap bean, string bean, green bean, French bean, runner bean, frijoles, habichuela

\* Pisum sativum L.[=P. arvense (L.) Poir.; P. hortense Aschers. and Graelen.]pea, garden pea, field pea, English pea, Chinese pea,  
edible-podded pea, sugar peaPsophocarpus tetragonolobus (L.) DC.goa bean, winged bean, asparagus bean, four-angled  
bean, Manila bean, princess pea

References: Aykroyd and Doughty 1966 p.11; Hedrick

1919 p.468; Herklots 1972 p.257; Purseglove 1968 p.315;

Uphof 1968 p.433.

Vicia ervilia (L.) Willd.[=Ervilia sativum Link.; Ervum ervilia L.]

bitter vetch, ervil

References: Aykroyd and Doughty 1966 p.112; Hedrick

1919 p.593; Uphof 1968 p.543.

\* Vicia faba L.[=V. esculenta Salisb.; Faba vulgaris Moench.]broad bean, fava bean, Windsor bean, field bean, horse  
bean, English bean, pigeon bean, tick beanVicia monanthos Desf.

bard vetch, monantha vetch

References: Aykroyd and Doughty 1966 p.112;

1919 p.596; Uphof 1968 p.543.

\* Vigna unguiculata (L.) Walp.

Usually considered the botanical parent of  
the two following "species".

Vigna cylindrica (L.) Skeels.

[=V. catjang Walp.; Dolichos catjang Burm.;

D. unguiculatus L.; Phaseolus cylindricus L.]

catjang, catjung, catjang cowpea, Hindu cowpea,  
China pea, Kaffir pea, marble pea, Jerusalem pea

Vigna sinensis (Stickm.) Savi ex Hassk.

[=Dolichos sinensis L.]

common cowpea, southern pea, black-eyed pea, black-eyed  
bean, crowder pea, cornfield pea, cherry bean

\* Voandzeia subterranea (L.) Thouars

bambara groundnut, earth nut, earth pea, groundnut, juga  
bean, Congo coober, Madagascar peanut

## 2. MAJOR PULSE CROPS OF THE WORLD

## a) Descriptions and Uses of 14 Species

Arachis hypogaea L.

Peanut

Peanuts are native to Brazil and were domesticated in much of the Western Hemisphere at the time of the first European explorers. They were taken to Africa by the Portuguese and to the orient in Spanish ships via the Pacific (Purseglove 1968).

The peanut is often considered as an oil crop rather than as a pulse, owing to the extensive use of its oil in both food and industrial applications. Peanut oil is second only to soybean oil in worldwide economic importance. However, in addition to the cash value of the oil, the peanut's high protein, calorie, and B-vitamin content make it a very important local food crop in the drier areas of Africa and Asia. There are also substantial quantities grown in the southern United States, mostly for peanut butter. Peanuts are eaten raw, roasted, and as flour. Both the hay and the "cake" left after oil extraction make high-quality animal feed.

Peanuts grow best in light soils in warm areas where rainfall is not excessive, particularly during the flowering period. They are known for their ability to utilize soils poor in phosphorus and their response to additions of nitrogen, calcium, sulfur, and potassium is erratic (Purseglove 1968). The roots are usually heavily nodulated with nitrogen-fixing bacteria. As

with many legumes, the practice of inoculating the seed with the bacteria gives varying results under different conditions.

In most of the world peanuts are intercropped with large grains such as maize or millet and the cultivation is done with simple machinery or hand tools. Intensive specialized mechanization and peanut monocultures have been common mainly in highly industrialized countries such as the United States.

Peanuts are often botanically divided into two groups. The prostrate runner and spreading bunch forms include the "Virginia" and many of the African cultivars. Branching is sequential and seed dormancy must be broken before germination. The growing season is five to six months and they are the preferred type for roasting.

Many of the more common commercial cultivars are erect bunch forms, especially those grown for oil extraction such as the "Spanish" and "Valencia" types. Branching is alternate and the nuts are closer to the plant's base, allowing for easier digging at harvest. The season is shorter, commonly three to four months.

Genetic improvement has proven difficult with peanuts due to their tendency toward self-fertilization before the flowers open. Only about 20 selected cultivars are grown in the world and often a very few make up the majority of a country's production (National Research Council 1972).



*Arachis hypogaea* (continued)

Selected references: Acland 1972 p.118; Arant 1951; Feakin 1973; Harrison et al. 1969 p.22; Herklots 1972 p.228; Janick 1969 p.372; McIlroy 1963 p.78; Magnes et al. 1971 p.16,183; Masefield 1965 p.33; Mortensen and Bullard 1964 p.146; National Research Council 1972 p.217; Purseglove 1968 p.225; Tindall 1968 p.167; Whyte et al. 1953 p.255; Woodroof 1973.

Cajanus cajan (L.) Millsp.

Pigeon Pea

The pigeon pea is a major pulse throughout much of the tropics. Its seeds have been associated with Egyptian ruins of the second millenium B.C., indicating its ancient domestication (Purseglove 1968). It is the second most important bean in India, where it is eaten in the pod as a vegetable, dried and boiled as a pulse, or made into dhal, a staple food item in southern Asia (Aykroyd and Doughty 1966). Dhal includes several methods of preparing decorticated pulses. Generally a paste is made from the split, soaked, dry beans before various cooking techniques are used to prepare a variety of dishes. Pigeon peas are usually produced for local markets, although associated canning industries occur in several countries.

The plants are frost-sensitive, short-lived perennials reaching a height of 1 to 4 m. Their deep roots make them drought resistant and they can do well on many soil types.

Pigeon pea is the only pulse greatly influenced by outcrossing, up to 40 percent of the flowers being affected by pollinating insects. The plants are sown either by broadcasting or by interplanting every few rows among crops such as sorghum, millet, maize, or sesame (Purseglove 1968).

Many cultivars are grown throughout the tropics and over 100 occur in India alone. They can be separated into two groups on the basis of botanical and cultural characteristics. C. cajan flavus DC. is early maturing and suitable as a single season crop and is grown as such in southern India. C. cajan bicolor DC. is taller and is cut back after the first year's crop is harvested so that a second growth will develop. It is the dominant type in northern India.

Genetic improvement of the cultivars has been limited to date, but selection is underway on several continents for higher yields, more exploitable cultural characteristics and disease resistance.

Selected references: Aykroyd and Doughty 1966 p.102; Commonwealth Bureau of Pasture and Field Crops [date unknown]; Harrison et al. 1969 p.34; Hedrick 1919 p.124; Herklots 1972 p.232; Masefield 1965 p.35; Mortensen and Bullard 1964 p.151; National Research Council 1972 p.217; Purseglove 1968 p.236; Senewiratne and Appadurai 1966 p.153; Tindall 1968 p.208; Whyte et al. 1963 p.256.

Cicer arietinum L.

Gram, Chickpea

This bean was familiar to the early civilizations around the eastern Mediterranean and is now grown in limited amounts throughout the world. Gram is the primary pulse in India where it is often consumed after being processed into dhal.

Gram is a cool weather crop when grown in the tropics or a summer crop in more temperate regions. It is sown as a pure stand or mixed with cereals (Whyte et al. 1953). Its adaptability to clay-loam soils allows it to be rotated with lowland rice, although it does best in a moderately dry climate. The general cultural requirements are much like that of the common bean, Phaseolus vulgaris.

Only one or two seeds are produced per pod and the young pods are sometimes served as a vegetable. A type of vinegar consisting of malic and oxalic acid is collected in India by spreading cloths over the plants at night to collect the plants "exudations" trapped in the morning dew (Purseglove 1968).

There has been relatively little selection work carried out to identify or develop superior cultivars, although such work is now underway in India and Iran.

Selected references: Aykroyd and Doughty 1966 p.103; Commonwealth Bureau of Pasture and Field Crops [date unknown]f; Harrison et al. 1969 p.38; Herklots 1972 p.236; Masefield 1965 p.37; Mortensen and Bullard 1964 p.130; Purseglove 1968 p.246; Senewiratne and Appadurai 1966 p.173; Sevey 1915 p.1; Whyte et al. 1953 p.262.

Glycine max (L.) Merr.

Soybean

The soybean is one of the oldest known cultivated crops and was mentioned in the literature of its native China in 2838 B.C. China still produces about 30 per cent of the world's crop, with the United States accounting for 60 per cent. It is the foremost source of vegetable oil in the world and the left-over protein cake is an important food supplement for livestock (Purseglove 1968). Soybean's high protein content will make it increasingly valuable as a food source for humans.

Soybean has almost a "complete" protein complement, being fairly high in the essential amino acid lysine which is in short supply in most other grains and legumes. Unfortunately, its high oil content and secondary chemicals make it difficult to cook palatably. It has therefore not become accepted in many cultures where the local pulses are preferred. Special processing techniques enable the bean to be used as milk, flour, or curd, but this requires either a knowledge of traditional oriental methods or fairly high levels of food processing technology (Aykroyd and Doughty 1966).

Soybean is grown under highly mechanized and intensive culture in the midwestern and southeastern United States, where it is often rotated with corn. In Manchuria it is rotated with sorghum or millet and in parts of southern Asia with rice (Purseglove 1968). The strain of symbiotic nitrogen-fixing bacteria that nodulates the roots is specific to soybean, whereas most other cultivated legumes can be cross-inoculated to

some extent. Increased yields are often noticed after several years of cropping, perhaps due to a build-up of these beneficial bacteria in the soil.

Soybean is basically a temperate-region crop since the pods of most cultivars do not fill properly in the tropics. However, progress is being made in the selecting of types suitable to tropical conditions. Thousands of cultivars are known, but less than a hundred are grown in the USA. Most of these are the progeny of a dozen or so of the best cultivars brought from China between 1900 and 1930. The limited genetic base in the bulk of soybeans commercially grown in the USA could potentially be a factor in an epidemic of plant disease should a more virulent form of a disease develop or be introduced. (National Research Council 1972).

Selected references: Commonwealth Bureau of Pasture and Field Crops [date unknown]; Godfrey 1974; Harrison et al. 1969 p.24; Herklots 1972 p.238; Janick 1969 p.370; Kipps 1970 p.39; McIlroy 1963 p.80; Masefield 1965 p.35; Mortensen and Bullard 1964 p.122; National Research Council 1972 p.209; Purseglove 1968 p.265; Senewiratne and Appadurai 1966 p.161; Tindall 1965 p.100; Ware and McCollum 1968 p.518; Whyte et al. 1953 p.275.

Lablab niger Medik

Hyacinth Bean

This tall, herbaceous plant is cultivated in the tropics as a vegetable or pulse crop and is also a major source of livestock feed. Most all consumption is local.

In its native southern Asia two basic types of plant are distinguishable throughout the many unselected lines. L. niger lablab L. is grown on stakes to support the twining branches that produce tender green pods used as a vegetable. L. niger lignosus (L.) Prain is preferred for field production of beans and fodder where its erect bushy form and drought resistance are desirable. It is grown in the Sudan in rotation with cotton and sorghum and is commonly intercropped with the cereal Eleusine spp. in India (Purseglove 1968).

Both forms of hyacinth bean are perennials grown as annuals and the photoperiod response varies widely. Genetic improvement appears to be a difficult problem, since 25 years of selection work in the Sudan did not significantly improve upon the local unselected types.

Selected references: Aykroyd and Doughty 1966 p.15; Commonwealth Bureau of Pasture and Field Crops [date unknown]; Harrison et al. 1969 p.44; Hedrick 1919 p.245; Herklots 1972 p.241; Magnes et al. 1971 p.40; Mortensen and Bullard 1964 p.12; Purseglove 1968 p.273; Schaffhausen 1963; Tindall 1965 p.98; Tindal 1968 p.98; Whyte et al. 1953 p.272.

Lens esculenta Moench.

Lentil

Lentils are another crop of ancient husbandry, having been found in Egyptian tombs dated before 2000 B.C. (Aykroyd and Doughty 1966). The seeds are usually consumed as flour or in soup, but in India dhal is prepared from them and the green pods are used as a vegetable.

Lentils are grown in large quantities only in the Middle East and South Asia. The plants are not suited to the wet tropics. They are usually grown as a mixed crop with upland rice or other cereals.

In general, large-seeded cultivars are common around the Mediterranean, smaller-seeded forms being more common in southern Asia (Purseglove 1968). Selection work for superior cultivars is only beginning.

Selected references: Aykroyd and Doughty 1966 p.106; Commonwealth Bureau of Pasture and Field Crops [date unknown]; Harrison et al. 1969 p.42; Hedrick 1919 p.331; Magnes et al. 1972 p.46; Purseglove 1968 p.279; Senewiratne and Appadurai 1966 p.176; Whyte et al. 1953 p.283; Wythes and Roberts 1906 p.53.

Phaseolus aureus Roxb.

Green Gram, Mung Bean

Phaseolus aureus is indigenous to southern Asia and is thought to be derived from the wild bean P. radiatus L. with which it is sometimes confused in the literature. It was an early introduction to southern China and South-East Asia and within the last hundred years has become an important crop in parts of central and southern Africa (Purseglove 1968). In the New World, green gram is usually grown for green manure or fodder, although the United States consumes about 12,200 tonnes of seed per year, mostly in the form of "Chinese bean sprouts". About one-half to two-thirds of these are imported from the Orient (Magness et al. 1971).

Green gram is considered in India to be the aristocrat of pulses because it lacks the "heaviness" often associated with the digestion of other beans. The green pods and leaves are consumed as a vegetable although primary use is made of the dried beans either whole or made into dhal or flour.

The cultivation of green gram usually begins at the end of the wet season and each year several crops are matured, taking two to four months each. Seed set is inhibited by rain or high humidity and the plants require a fairly well-drained soil (Tindall 1968). These factors plus a tolerance for moderate drought and heat make P. aureus a crop well adapted to the semi-arid tropics, or at least to areas with a pronounced dry season. Green gram is commonly grown in rotation with rice or intersown with sorghum.



Two groups of cultivars are recognized by Purseglove (1968). The yellow seeds of most "golden" gram cultivars are prone to ripen unevenly and to shatter. These types produce superior forage and green manure crops and several good pulse cultivars are known in India. The "green" gram types are the common pulse-producers. Many local cultivars of both types are known and there is still much potential for selection and breeding beyond the work carried out in India and the United States to date.

Selected references: Commonwealth Bureau of Pastures and Field Crops [date unknown] c,h; Harrison et al. 1969 p.38; Herklots 1972 p.245; Magnes et al. 1971 p.52; Purseglove 1968 p.290; Smith and Welch 1959 p.108; Tindall 1968 p.165; Whyte et al. 1953 p.303.

Phaseolus lunatus L.

Lima Bean

Peruvian graves of the fifth millenium B.C. have yielded seed identifiable as this species (Kaplan 1965). In post-Columbian times it was distributed throughout the world, and has become a major pulse in parts of Africa and South-East Asia.

The lima is often considered the most sensitive of the Phaseolus species. Its culture is most similar to that of the

common bean, but it needs a balmy climate, frost-free for three to nine months but not above 27° C during the flowering period. Some cultivars are day-neutral, although the better ones are short-day plants.

These beans are either tall climbers with large seeds or smaller bush forms producing "sieva" or "baby" limas. There is a great array of sizes, shapes, and colors inherent in this species, as in most others. However, the canning and freezing industry in the United States has developed very standardized cultivars. From these lines have come many of the cultivars now commercially grown throughout the world (National Research Council 1972).

Some genetic lines of lima bean contain dangerous amounts of an enzyme and substrate capable of liberating hydrocyanic acid (HCN). Soaking the beans for 24 hours or thorough cooking destroys the enzyme. The white-seeded cultivars are usually below the danger level of 100 ppm HCN (Herklots 1972 p.227).

Selected references: Aykroyd and Doughty 1966 p.109; Commonwealth Bureau of Pasture and Field Crops [date unknown]; Harrison et al. 1959 p.38; Hedrick 1919 p.418; Herklots 1972 p.249; Kaplan 1965 p.358; Mortensen and Bullard 1964 p.121; Purseglove 1968 p.228; Sevey 1918; Tindall 1965 p.97; Tindall 1968 p.111; Uphof 1968 p.400; Ware and McCollum 1968 p.227.

Phaseolus mungo L.

Black Gram

Black gram is a preferred dry pulse in parts of East Africa and in its native India, particularly in the region around Mysore state. Confused in the older literature with the mung bean (P. aureus Roxb.), they are now considered distinct, if sibling species. In addition to being a common source of dhal, black gram is valuable for its ability to provide leavened cakes due to the presence of a gluten-like material in the bean's flour (Purseglove 1968).

The plant requires a growing season without extensive rain although its ability to withstand drought varies among cultivars. It grows well in clay soils of rough tilth and so can be rotated with wet rice. Mixed cultivation is also commonly employed.

The early-maturing cultivars produce black seeds and grow at altitudes of up to 1830 m. These cultivars are considered superior to the late-maturing types which have olive-green seeds (easy to confuse with P. aureus). Selection of superior cultivars has not been extensive in India. A prime objective of present work is to obtain a line with a single harvest time.

Selected references: Aykroyd and Doughty 1966 p.109;  
Commonwealth Bureau of Pasture and Field Crops [date unknown]g;  
Herklots 1972 p.251; Purseglove 1968 p.301; Senewiratne and Appadurai 1966 p.170.

Phaseolus vulgaris L.

## Common Bean

Remains of this species have been found throughout Latin America in archeological excavations. One of the oldest from a cave in Mexico was radiocarbon dated ca. 4900 B.C. The earliest European explorers found it throughout the Americas and it was spread through Europe in the 16th century and to the rest of the Old World soon thereafter (Purseglove 1968).

Common beans are the best known and most widely cultivated of all the pulses, although the people of the old world tropics often prefer to cultivate their indigenous legumes.

P. vulgaris is most productive in temperate climates where the plants can mature slowly without getting much precipitation. They are therefore most important in the temperate regions and at high altitudes or during cooler seasons in the tropics. Soil type may vary widely, as long as it remains damp but well-drained. The extent of root nodulation fluctuates, especially in areas where the species does not have a long history of cultivation. Inoculation with the symbiotic bacterium under such conditions has produced erratic results.

Its nitrogen-fixing ability and twining habit have made the common bean a favorite crop to be interplanted with the larger grains, such as maize and millet, except in mechanized North American agriculture. Rotation with other crops often must be practiced to keep soil-borne diseases in check. The best seed grows in dry, disease-free areas, such as found in Tanzania and California.

The species is highly polymorphic but is divisible into two types. The dwarf or bush cultivars are early maturing and day-neutral. The climbing or pole cultivars take longer to mature but have a longer bearing season and can produce a better crop under conditions of higher rainfall. Short-day and day-neutral cultivars are both commonly found in the climbing group. Beans are also classified according to their use as a vegetable, e.g. immature pods of string beans, or as a grain legume harvested after the seeds have dried.

Extensive selection to develop the most uniform and productive cultivars has taken place in the temperate regions. Relatively little work of this type has been done for the tropics, although it is becoming a more common area of research as the world food situation becomes more critical. Latin America, the original source of P. vulgaris and the world's largest producer, is the region of greatest potential for research on this species. In the United States, a significant producer of dry beans, about 60 per cent of the crop comes from cultivars stemming from three major sources of germ plasm (National Research Council 1972). The "landraces" (traditionally selected cultivars) of Latin America and Africa have much more inherent variability and so are less prone to disease epidemics. However, they also have serious drawbacks, such as a high percentage of beans that do not soften with boiling and a lack of the crop standardization needed for a modern processing industry.

Phaseolus vulgaris (continued)

Selected references: Acland 1972 p.20; Aykroyd and Doughty 1966 p.109; Bland 1971 p.265; Commonwealth Bureau of Pasture and Field Crops [date unknown]; Harrison et al. 1969 p.36; Hedrick 1919 p.422; Herklots 1972 p.252; Kaplan 1965 p.358; Kipps 1970 p.431; Knott 1962 p.215; Mortensen and Bullard 1964 p.120; National Research Council 1972 p.224; Purseglove 1968 p.34; Schery 1974 p.453; Sevey 1918; Tindall 1965 p.98; Tindall 1968 p.104; Ware and McCollum 1968 p.227.

Pisum sativum L.

Pea

Peas are grown both as a secondary source of dried pulse and as a vegetable throughout the temperate regions and above 1220 m in the tropics (Purseglove 1968). They are of ancient domestication, having been identified from archaeological digs in Switzerland (ca. 4500 B.C.), as well as from early Egypt and Troy (Aykroyd and Doughty 1966). It is a cool season crop which requires moist soil during flowering and moderate temperatures for seed set.

The species contains two major divisions which are sometimes given specific ranking, but their complete inter-fertility makes it best to consider them as two subspecies or groups of cultivars. P. sativum arvense (L.) Poir, the field pea, is a relatively hardy type whose seeds are harvested dry for use whole, split, or as flour. The garden vegetable pea,

P. sativum hortense (L.) Poir, is normally a larger plant than its field-grown cousin but is more sensitive to cold and drought. It became a popular vegetable in Europe only after the 16th century, Aykroyd and Doughty (1966) report there being a fad for it at the court of King Louis XIV. Some cultivars lack the papery lining inside the pod and so the entire legume is edible.

The development of cultivars has been extensive in the temperate zone, some work having been done for the tropics. The harvesting and processing of green peas in industrial countries is highly mechanized resulting in a need for uniform cultivars. An estimated 96 per cent of the green pea crop in the United States is grown from two sources of genetic material, dry peas having only a slightly wider background (National Research Council 1972).

Selected references: Aykroyd and Doughty 1966 p.109; Bland 1971 p.326; Harrison et al. 1969 p.42; Hedrick 1919 p.441; Herklots 1972 p.254; Kipps 1970 p.436; Mortensen and Bullard 1964 p.147; National Research Council 1972 p.244; Purseglove 1968 p.311; Tindall 1968 p.198; Ware and McCollum 1968 p.355; Whyte et al. 1953 p.305.

Vicia faba L.

## Broad Bean

The broad bean is known to have been grown by the early civilizations around the Mediterranean and was the only bean commonly eaten in northern Europe before contact with the New World introduced the common and lima beans. Broad beans may have been spread to China as early as 2822 B.C. (Hedrick 1919) and are now established throughout the world. Broad beans are an important crop for both animal and human food throughout Europe, Africa, and the Middle East.

Being a temperate plant, flowering is adversely affected by hot or dry weather and it has difficulty setting seed under hot, humid conditions (Aykroyd and Doughty 1966). In some tropical situations it does well in the cool season or at higher altitudes. The growing season can be three to seven months, depending on climate. Soil preference ranges from moderate to heavy clay, liberal moisture being required. Tolerance to soil salts is superior to most other beans.

The many cultivars are grouped according to such questionable botanical characteristics as seed size. Commonly, a distinction is made between the small "pigeon pea" (V. faba minor), the larger "horse bean" (equina), and the yet larger "fava" or common broad bean (major). Breeding work on this crop is not advanced. Selection, hybridization, and even inter-specific crosses are possible means of increasing yield, resistance to pests, self-fertility, and protein complement (Bond 1970). Most such work to date has taken place in Europe.



Vicia faba (continued)

Selected references: Aykroyd and Doughty 1966 p.112; Bland 1971 p.264; Commonwealth Bureau of Pasture and Field Crops [date unknown]b; Harrison et al. 1969 p.40; Hedrick 1919 p.593; Herklots 1972 p.260; Magnes et al. 1971 p.65,197; Mortensen and Bullard 1964 p.119; Purseglove 1968 p.319; Tindall 1968 p.101.

Vigna unguiculata (L.) Walp.

Cowpea

The cowpea is believed to have evolved in Africa and thence spread to the Near East early enough to be mentioned in Sumerian records dated ca. 2350 B.C. (Herklots 1972). It was the "phaseolus" bean of the Roman Empire and was spread eastward to China and Malaya in unrecorded times. Early explorers of the New World completed its dispersal throughout the tropics and sub-tropics.

The cowpea is a primary pulse for much of the world, particularly Africa. It is better adapted to conditions of dry heat than the common or lima beans: wet weather results in vegetative growth and a susceptibility to fungus diseases. Seed germination requires warm soil and the plant is not frost tolerant. It is a vigorous grower under good conditions, even crowding out the seriously aggressive weed Imperata cylindrica (L.) Beauv. (Stanton et al. 1966; Whyte et al. 1953). Although most importantly a pulse crop, its indeterminate growth characteristic allows the leaves to be regularly picked for use as a vegetable.

In the tropics, cowpeas are commonly interplanted with maize, sorghum, millet, or sudan grass. Monocultures are preferred in the southeastern United States and California where cowpeas are often rotated with cotton or maize. Cowpeas do best on a rich, well-drained soil, but they can survive adequately on poor sites and so are often used as a soil improver.

Pods mature in three to five months, depending on the cultivar. The tendency for cowpeas to ripen over a period of time makes a single harvest difficult. Much of the selection for better cultivars has revolved about this problem, in addition to developing resistance to pests and increased yields.

Both domesticated types of cowpea (V. sinensis and V. cylindrica) are interfertile and are thought to be derivatives of, if not synonymous with, V. unguiculata (L.) Walp., the wild African cowpea (Purseglove 1968). A sibling species, V. sesquipedalis (L.) Fruw., is known as the yard-long bean and is commonly grown as a vegetable in the tropics. V. cylindrica, the more primitive of the two domesticated cowpeas, includes a myriad of landraces in Africa, each showing great variety in seed size and color. The Chinese call it the "horn bean" due to the tendency for the young pods to remain erect on the stem. In contrast, V. sinensis, the type most commonly commercially cultivated throughout the world, has pods that quickly become pendant (Herklots 1972).

Vigna unguiculata (continued)

Selected references: Aykroyd and Doughty 1966 p.112;  
 Commonwealth Bureau of Pasture and Field Crops [date unknown]k;  
 Harrison et al. 1969 p.44; Herklots 1972 p.260; Kipps 1970 p.425;  
 Magnes et al. 1971 p.66; Mortensen and Bullard 1964 p.159;  
 Purseglove 1968 p.321; Sellchop 1962 p.259; Senewiratne and  
 Appaduræ 1966 p.147; Sevey 1915 p.59; Stanton et al. 1966 p.35;  
 Summerfield et al. 1974; Tindall 1965 p.96; Tindall 1968 p.144;  
 Whyte et al. 1953 p.342.)

Voandzeia subterranea (L.) Thours. Bambara Groundnut

The bambara groundnut is similar to the peanut (Arachis hypogaea) in both culture and gross morphology. It was an important indigenous pulse of sub-Saharan Africa but is increasingly being displaced by the more productive peanut (Aykroyd and Doughty 1966). Although Europeans spread the bambara groundnut to South America in the 17th century and to Southeast Asia in the 18th, it has not become important outside of central Africa. All the crop is consumed locally and it is not used as a source of vegetable oil (Purseglove 1968).

The plant is short and bunchy, with underground pods containing one or two seeds near the base. As explained by Purseglove (1968), the underground fruit is significantly different in etiology from the peanut. At harvest the plants are pulled and the pods collected "green" or first allowed to dry in

the sun. The green seeds are eaten after soaking and boiling and are easier to cook than ripe seeds, which are often roasted and ground to flour.

Bambara groundnuts do well on a light, sandy soil but their hardiness allows them to be the first crop grown on poor, newly cleared land. They are tolerant of high temperature and drought and their freedom from serious insect or disease pests should make them of particular interest to plant breeders. Several traditionally selected cultivars occur in central Africa.

Selected references: Aykroyd and Doughty 1966 p.113; Commonwealth Bureau of Pasture and Field Crops [date unknown]a; Harrison et al. 1969 p.34; Hepper 1970; Purseglove 1968 p.329; Tindall 1968 p.170; Whyte et al. 1953 p.344.

b) Tabulated Information on Agronomic Characteristics,  
Nutritional Values, and World Production Figures

Specific botanical and cultural characteristics of the major species of pulses previously described are arranged for comparison in Table I. Similar but more extensive compilations are provided by Rachie (1973) and Whyte et al. (1953 p.358).

Pulses are a major source of protein for much of the world's population and impending chronic food shortages will make them of even greater importance. The role of legumes in human nutrition was examined by Aykroyd and Doughty (1966) in a very readable report published by the Food and Agriculture Organization of the United Nations. Other interesting studies on the culinary aspects of pulses were done by Keys and Keys (1967) and Dragonwagon (1972).

The relative proportion of essential amino acids determines a protein's usefulness to the body. Harvey (1970) consolidated the literature on analyses of amino acids for pulses and other foods. Lappe (1971) explains how to combine the protein ratios of foods of vegetable origin to obtain an increase in available protein. The per cent protein, carbohydrate, and fat of the 14 major pulses are provided in Table II.

The world production of several of the most valuable pulse crops is quantified in Tables III, IV, and V. The figures are the most recent available from the Food and Agriculture Organization. The relative productivity of the various continents was calculated from the original data for each crop

in terms of tonnes (metric tons) per hectare. Such productivity data is useful for determining the potential and/or probable per cent contribution each crop and region makes to the world's food requirements. It also shows the differences that the production technology available in developed countries can make to yields.

TABLE I. Tabulated General Information on Major Pulse Crops.

Species	Life span	Growth form	Part eaten	Chromosomes	Photoperiod	Output	Origin	Distribution	Major producing areas	Yield (kg/ha)
<u>Arachis hypogaea</u>	a	h	gs, ds	tet 40	?	0-6	Brazil	TR, ST	China, India, USA, Nigeria	450-2300
<u>Cajanus cajan</u>	p (a)	w	gs, ds	dip, tet, hex 22	s	5-40	Africa	TR	India, Africa, Carib.	560-1120
<u>Cicer arietinum</u>	a	h	ds, GP	dip 16	n	0+	Mid East	TR, ST	India, Mid East	450-1600
<u>Glycine max</u>	a	h	gs, ds	tet 40	s, l	1	E Asia	ST, ST	USA, E and SE Asia	500-2700
<u>Lablab niger</u>	p (a)	h	ds, GP	dip 22,24	?	0+	Asia	TR	India, N Africa, S America	450-1450
<u>Lens esculenta</u>	a	h	ds, GP	dip 14	s,	0+	Mid East	TP, ST	Mid East, S Asia	600-1680
<u>Phaseolus aureus</u>	a	h	ds, GP	dip, tet 22	s, l		India	TP, TR	S Asia, China, E Africa	450-1120
<u>Phaseolus lunatus</u>	a, p	h	gs, ds, GP	dip 22	n	0-18	S and Cent. America	TR, TP	USA, Africa, SE Asia	1350-1680
<u>Phaseolus mungo</u>	a	h	ds, GP	dip 22,24	n, s	0	India	TR	India	200-900
<u>Phaseolus vulgaris</u>	a	v, h	gs, ds, GP	dip 22	n, s	0	S Amer.	TR, TR	Latin, N Amer., Africa	225-1350
<u>Pisum sativum</u>	a	v	gs, GP	dip 14	?	0	E Med., Cent. Urasia	TR, TR	USSR, E Asia, Europe	400-2000
<u>Vicia faba</u>	a	h	ds	dip 12,14	?	0-30	E Med.	TP	Europe, Mid East	560-2700
<u>Vigna unguiculata</u>	a	h, v	ds	dip 22,24	s	0+	Africa, S Asia	TR, ST	Africa, S Asia, USA	450-2800
<u>Voandzeia subterranea</u>	a	h	ds	dip 22	?	0	W Africa	TR	Africa	560-1120

Key to Symbols:

a = annual	s. = short-day
p = perennial	l = long-day
h = herbaceous	n = day-neutral
v = vine-like	TR = tropical
w = woody	TP = temperate
gs = green seeds	ST = sub-tropical
ds = dry seeds	dip = diploid
GP = green pods	tet = tetraploid
	hex = hexaploid

Data gathered from the many references given for each species in Chapter I.  
 Photoperiod data from Allard and Zaumeyer 1944; Pursglove 1968.  
 Chromosome data from Darlington and Wylie 1955; Pursglove 1968.

TABLE II. Nutritional Values of 14 Species of Dried Pulses.

Species	Per Cent by Weight (to nearest whole number)		
	Protein	Carbohydrate	Fat
<u>Arachis hypogaea</u> peanut	26 to 30	12 to 19	45 to 48
<u>Cajanus cajan</u> pigeon pea	19 to 20	57 to 64	1 to 2
<u>Cicer arietinum</u> gram	17 to 20	61	5
<u>Glycine max</u> soybean	30 to 35	14 to 33	13 to 18
<u>Lablab niger</u> hyacinth bean	21 to 25	60 to 65	1
<u>Lens esculenta</u> lentil	24 to 25	59 to 60	1
<u>Phaseolus aureus</u> green gram	22 to 24	57 to 58	1
<u>Phaseolus lunatus</u> lima bean	20 to 21	57 to 64	1 to 2
<u>Phaseolus mungo</u> black gram	23 to 24	56 to 57	1
<u>Phaseolus vulgaris</u> common bean	22 to 24	57 to 62	1 to 2
<u>Pisum sativum</u> pea	22 to 25	57 to 60	1
<u>Vicia faba</u> broad bean	23 to 25	48 to 60	1 to 2
<u>Vigna unguiculata</u> cowpea	22 to 23	57 to 60	1 to 2
<u>Voandzeia subterranea</u> bambara groundnut	16 to 21	50 to 62	4 to 7

Sources: Platt 1962; Purseglove 1968; Watt and Merrill 1966.



Table III. World Production Figures for All Pulses,  
Dry Beans, and Dry Peas, 1971.

	All Pulses		Dry Beans*		Dry Peas	
	1000 tonnes	t/ha	1000 tonnes	t/ha	1000 tonnes	t/ha
Europe (incl. USSR)	10020.	ND	...	...	...	...
Europe	...	...	828.	0.3	635.	1.6
USSR	...	...	70.	1.8	4670.	1.4
N America	1090.	ND	801.	1.4	230.	2.0
Latin America	4400.	ND	3832.	0.6	101.	0.7
Near East	1460.	ND	193.	1.4	101.	0.7
Far East (incl. China)	21700.	ND	...	...	...	...
Far East	...	...	2637.	0.3	796.	0.8
China	...	...	1423.	0.7	3400.	1.0
Africa	4200.	ND	1235.	0.7	404.	0.7
Oceania	80.	ND	4.	0.8	70.	1.6
World	43000.	ND	11023.	0.5	10316.	1.1

\* Phaseolus vulgaris, P. lunatus,  
P. mungo, and P. aureus.

ND = no data

Sources:

All Pulses - Food and Agriculture Organization 1973c.

Dry Beans and Peas - Food and Agriculture Organization 1973a.

TABLE IV. World Production Figures for  
Soybeans and Groundnuts, 1971.

	Soybeans		Groundnuts (in shell)	
	1000 tonnes	t/ha	1000 tonnes	t/ha
Europe (incl. USSR)	...	...	23.	1.9
Europe	185.	1.1	...	...
USSR	ND	ND	...	...
N America	32285.	1.8	1363.	2.3
Latin America	2468.	1.3	1542.	1.3
Near East	18.	1.2	519.	1.0
Far East	1147.	0.7	7223.	0.8
China	11741.	0.8	2678.	1.2
Africa	14.	0.5	5844.	0.8
Oceania	9.	1.3	31.	0.8
World	48402.	1.3	18051.	0.9

ND = no data

Source: Food and Agriculture Organization 1973b.

TABLE V. World Production Figures for Broadbeans  
Chickpeas, and Lentils, 1970.

	Broadbeans		Chick Peas		Lentils	
	1000 tonnes	t/ha	1000 tonnes	t/ha	1000 tonnes	t/ha
Europe (incl. USSR?)	918.	1.3	169.	0.6	...	...
Europe	...	...	...	...	58.	0.7
USSR	...	...	...	...	80.	1.3
N America	ND	ND	ND	ND	33.	1.3
Latin America	164.	0.8	180.	0.5	30.	0.6
Near East	35.	1.8	186.	0.8	233.	0.7
Far East (incl. China?)	11.	1.2	6173.	0.7	462.	0.5
China	ND	ND	ND	ND	ND	ND
Africa	371.	0.9	364.	0.6	132.	0.5
Oceania	ND	ND	ND	ND	ND	ND
World	5123.	1.1	7072.	0.7	1028.	0.6

ND = no data

Source: Food and Agriculture Organization 1972.

## II. INSECT PESTS OF PULSE CROPS

## 1. INSECT-PLANT SPECIALIZATION AND TYPES OF DAMAGE

The pulses are associated with an insect fauna that is usually capable of survival on several or all legumes. This is largely due to the close phylogenetic relationship between the pulses. The legume family has had sufficient geographical diversity over a long period of time for many insect species to become well adapted to it. For example, the pea aphid (Acyrtosiphon pisum), the Mexican bean beetle (Epilachna varivestis), and most members of the family Bruchidae (bean "weevils") exclusively live on legumes.

The different geographical origins of the economically important pulse genera have allowed close insect-host relationships to develop. The numerous species of Phaseolus, despite their variety and widespread range, are in most cases similar in susceptibility to each other's pests. Other pulse genera, such as Arachis, Glycine, Vicia, and Vigna, also have a complement of insects that feed preferentially within the genus. As the plants and insects were redistributed throughout much of the world by both man and nature, many of the insects adapted to legumes other than their native host. Still, each of the legume genera has its own specific insect contingent in addition to hosting the more general legume feeders.

Many of the insects most damaging to pulses also inflict

large losses on other crops. Examples of such polyphagous feeders whose wide host range show either a lack of discrimination or a wide variety of acceptable stimuli are the armyworms and fruitworms of the noctuid family and several pentatomids and mirids.

Defining the usual and absolute host ranges of the insects attacking pulses is beyond the scope of this paper. It would also not be a very useful means of generalizing about the insects, for the majority of the most economically important ones are not highly discriminatory between most pulses.

A more useful method of describing pulse pests is in terms of the type of damage that they inflict on the host. Generalities can thereby be made on species filling similar ecological niches in different geographical locations. Undoubtedly, many insect pests of pulses that are locally important in certain parts of the world have been unknowingly omitted from the list presented in the second section of this chapter. However, it is likely that a closely related species, probably in the same genus, is included. Often when working with an ill-defined pest complex, it is frequently necessary to extrapolate from related species that have previously been studied more thoroughly. This is, of course, not a substitute for life history studies of the local pest's ecology. It seems to be the nature of insects to appear more ecologically complex as they are more closely studied, so one should not rest on assumptions gathered from "similar" material any more than is made necessary by lack of data.

Ranking insects by their actual or potential damage to pulses is not easy. Some insects, such as the locusts, are well known for their ability to reach massive populations during certain years and so cause considerable damage. However, pest species that are recurring, serious problems over widespread areas undoubtedly are more important from the viewpoint of entomological research on pulses per se. The types of damage done to pulses could be classified in several ways, considering the variety of species of host plants, pests, and locations dealt with in this paper. Six divisions based on the part of the host plant attacked are used here. Only those genera that contain the most important pest species for each type of damage are given in Table VI. The decision to include a genus was primarily based on its geographical and host range and damage potential. This list provides a basic guide to the many species referenced in the next section of this chapter.

TABLE VI. Insect Genera Causing Greatest Damage to Pulse Crops

## Insects Damaging Flowers and Buds

<u>Acrosternum</u>	(Hemiptera: Pentatomidae)
<u>Euschistus</u>	(Hemiptera: Pentatomidae)
<u>Nezara</u>	(Hemiptera: Pentatomidae)
<u>Lygus</u>	(Hemiptera: Miridae)
<u>Acanthomia</u>	(Homoptera: Coreidae)

## Insects Damaging Developing and Mature Pods

<u>Heliothis</u>	(Lepidoptera: Noctuidae)
<u>Spodoptera</u>	(Lepidoptera: Noctuidae)
<u>Maruca</u>	(Lepidoptera: Pyralidae)

## Insects Damaging Leaves

<u>Locusta</u>	(Orthoptera: Acrididae)
<u>Locustana</u>	(Orthoptera: Acrididae)
<u>Nomadacris</u>	(Orthoptera: Acrididae)
<u>Cerotoma</u>	(Coleoptera: Chrysomelidae)
<u>Diabrotica</u>	(Coleoptera: Chrysomelidae)
<u>Plagioderma</u>	(Coleoptera: Chrysomelidae)
<u>Popillia</u>	(Coleoptera: Scarabaeidae)
<u>Autoserica</u>	(Coleoptera: Scarabaeidae)
<u>Agromyza</u>	(Diptera: Agromyzidae)
<u>Liriomyza</u>	(Diptera: Agromyzidae)
<u>Amsacta</u>	(Lepidoptera: Arctiidae)
<u>Estigmene</u>	(Lepidoptera: Arctiidae)
<u>Autographa</u>	(Lepidoptera: Noctuidae)
<u>Chorizagrotis</u>	(Lepidoptera: Noctuidae)
<u>Peridroma</u>	(Lepidoptera: Noctuidae)
<u>Spodoptera</u>	(Lepidoptera: Noctuidae)
<u>Lamprosema</u>	(Lepidoptera: Pyralidae)

## Insects Damaging Stems and Roots

<u>Hodotermes</u>	(Isoptera: Hodotermitidae)
<u>Melanagromyza</u>	(Diptera: Agromyzidae)
<u>Ophiomyia</u>	(Diptera: Agromyzidae)
<u>Phytomyza</u>	(Diptera: Agromyzidae)
<u>Colaspis</u>	(Coleoptera: Chrysomelidae)
<u>Sagra</u>	(Coleoptera: Chrysomelidae)
<u>Phyllophaga</u>	(Coleoptera: Scarabaeidae)
<u>Graphognathus</u>	(Coleoptera: Curculionidae)

TABLE VI. Insect Genera Causing Greatest Damage to Pulse Crops  
(continued)

Insects Damaging Seeds

<u>Acanthoscelides</u>	(Coleoptera: Bruchidae)
<u>Bruchus</u>	(Coleoptera: Bruchidae)
<u>Callosobruchus</u>	(Coleoptera: Bruchidae)
<u>Zabrotes</u>	(Coleoptera: Bruchidae)
<u>Apion</u>	(Coleoptera: Curculionidae)
<u>Sitona</u>	(Coleoptera: Curculionidae)
<u>Delia</u>	(Diptera: Anthomyiidae)
<u>Etiella</u>	(Lepidoptera: Pyralidae)
<u>Hylemya</u>	(Diptera: Anthomyiidae)
<u>Ephestia</u>	(Lepidoptera: Pyralidae)

Insects Damaging the Vascular System or Individual Cells

<u>Tetranychus</u>	(Acarina: Tetranychidae)
<u>Caliothrips</u>	(Thysanoptera: Thripidae)
<u>Hercothrips</u>	(Thysanoptera: Thripidae)
<u>Kakothrips</u>	(Thysanoptera: Thripidae)
<u>Thrips</u>	(Thysanoptera: Thripidae)
<u>Acyrtosiphon</u>	(Homoptera: Aphidae)
<u>Aphis</u>	(Homoptera: Aphidae)
<u>Pergandeida</u>	(Homoptera: Aphididae)
<u>Bemisia</u>	(Homoptera: Aleyrodidae)
<u>Cicadulina</u>	(Homoptera: Cicadellidae)
<u>Empoasca</u>	(Homoptera: Cicadellidae)
<u>Corythuca</u>	(Hemiptera: Tingidae)



## 2. LIST OF ARTHROPODS COMMONLY DAMAGING PULSE CROPS

\* = spelling, authority, etc., unconfirmed or missing

## a) Insects

Acanthomia horrida (Germ.) (Homoptera: Coreidae)

Hosts: Vigna unguiculata

References: Acland 1972 p.113.

A. tomentosicollis \*

Common name: bean bug

Hosts: "beans"

References: Smit 1964 p.134.

Acanthoscelides obtectus (Say) (Coleoptera: Bruchidae)

=Bruchus obtectus Say

Common name: common bean beetle or weevil,  
dried bean beetle

Hosts: all pulses

References: Metcalf et al. 1962 p.937; Davidson and Peairs  
1966 p.276; Wilson and Becker 1963 p.196,201; Avidov and  
Harpaz 1969 p.289; Rivnay 1962 p.214; de Pury 1968 p.132;  
Smit 1964 p.279, Acland 1972 p.23.

Aceratagallia sanguinolenta (Prov.) (Homoptera: Cicadellidae)

Common name: clover leafhopper

Hosts: Vigna unguiculata, "beans"

References: Davidson and Peairs 1969 p.257.

Achaea finita Gn.\* (Lepidoptera: Noctuidae)

Hosts: Arachis hypogaea

Wyniger 1962 p.347.

Acherontia styx Westw. (Lepidoptera: Sphingidae)

Common name: sphinx moth

Hosts: Phaseolus spp.

References: Wyniger 1962 p.193.

Acrosternum hilare (Say) (Hemiptera: Pentatomidae)

Common name: green stink bug

Hosts: Glycine max, P. lunatus, "beans"

References: Metcalf et al. 1962 p.547,578,621; Davidson and  
Peairs 1966 p.262; National Research Council 1972  
p.215.

Acyrtosiphon pisum (Harris) (Homoptera: Aphidae)

=Macrosiphum pisi (Kalt.)

=M. pisum (Harris)

Common name: pea aphid, green pea aphid

Hosts: Cicer arietinum, P. vulgaris, Pisum sativum,  
Vicia faba

References: Metcalf et al. 1962 p.626; Davidson and Peairs 1966 p.272; Gane et al. 1971 p.VI-10; Avidov and Harpaz 1969 p.108; National Research Council 1972 p.247; Rivnay 1962 p.210; Ware and McCollum 1968 p.363; Purseglove 1968 p.315; Commonwealth Institute of Entomology 1952; Trought 1965 p.16.

A. sesbaniae Kan. Dav.

Hosts: Vicia faba

References: Schmutterer 1969 p.94.

Adisura atkinsoni Moore

Common name: pod borer

Hosts: Lablab niger

References: Purseglove 1968 p.276.

Adoretus spp. (Coleoptera: Scarabaeidae)

Hosts: Lablab niger

References: Schmutterer 1969 p.126.

Agriotes spp. (Coleoptera: Elateridae)

Common name: wireworms

Hosts: all pulses

References: Gane et al. 1971 p.VI-5; Metcalf et al. 1962 p.618; Davidson and Peairs 1966 p.139; Wilson and Becker 1963 p.199; Gram et al. p.108.

Agromyza lathyri Hendel (Diptera: Agromyzidae)

Common name: pea leaf miner

Hosts: Pisum sativum

References: Gane et al. 1971 p.VI-15; Spencer 1973 p.87.

A. phaseoli Coq.

see Ophiomyia phaseoli (Tryon)

Agrotis ipsilon (Hufn.) (Lepidoptera: Noctuidae)

=A. ypsilon (Rot.)

Common name: black or greasy cutworm

Hosts: all pulses

References: Metcalf et al. 1962 p.477; Pradhan p.66.

A. pronuba \*

see Triphaena pronuba (L.)

Alcides arcuatus Bohem.\* (Coleoptera: Curculionidae)

Hosts: Arachis hypogaea

References: Wyniger 1962 p.343.

A. leucogramma (Erichs.)

Common name: striped bean weevil

Hosts: Phaseolus spp.

References: de Pury 1968 p.155; Wyniger 1962 p.189.

Amsacta albistriga Walk. (Lepidoptera: Arctiidae)

Common name: red hairy caterpillar

Hosts: Arachis hypogaeaReferences: Wyniger 1962 p.345; Purseglove 1968 p.233;  
Senewiratne and Appadurai 1966 p.357.Anisolabis spp. (Dermaptera: Labiduridae)

Common name: earwig

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.234.

Anoplocnemis curvipes (F.) (Hemiptera: Coreidae)Hosts: Arachis hypogaea, Vigna unguiculata

References: Schmutterer 1969 p.65.

Anticarsia gemmatalis (Mubn.) (Lepidoptera: Noctuidae)

Common name: velvetbean caterpillar

Hosts: Arachis hypogaea, Glycine max,  
Vigna unguiculataReferences: Davidson and Peairs 1966 p.272; National  
Research Council 1972 p.215; Purseglove 1968 p.271,233;  
Woodroof 1973 p.78.Aphanus sordidus F.\* (Hemiptera: Lygaeidae)

Common name: pod bug

Hosts: Arachis hypogaea

References: Wyniger 1962 p.352.

Aphis craccivora Koch (Homoptera: Aphidae)= A. laburni Koch

Common name: cowpea aphid

Hosts: Arachis hypogaea, Cicer arietinum, P. vulgaris,  
Pisum sativum, Vicia faba, Vigna unguiculataReferences: Acland 1972 p.22; Wilson and Becker 1963  
p.84,254; Wheatley 1965 p.153; Avidov and Harpaz 1969  
p.116; Tindall 1965 p.2.A. fabae Scop.

Common name: black bean aphid

Hosts: Glycine max, P. aureus, P. mungo,  
P. vulgaris, Vicia fabaReferences: Acland 1972 p.23,117; Metcalf et al. 1962  
p.621,873; Wilson and Becker 1963 p.63; Avidov and Harpaz  
1969 p.118; Trought 1965 p.19.A. gossypii Glover

Common name: melon aphid, cotton aphid

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.120; Rivnay 1962 p.63.

A. laburni Kochsee Aphis craccivora Koch

Apion aestivum Germ. (Coleoptera: Curculionidae)

Common name: clover apion

Hosts: P. vulgaris, Pisum sativum

References: Avidov and Harpaz 1969 p.290.

A. arrogans Wenk.

Common name: legume apion

Hosts: Pisum sativum, Vicia faba

References: Avidov and Harpaz 1969 p.290.

Autographa californica (Speyer) (Lepidoptera: Noctuidae)

Common name: alfalfa looper

Hosts: Vigna unguiculata

References: Davidson and Peairs 1966 p.267.

A. chalcites \*see Plusia chalcites (Esp.)A. egena \*see Syngrapha egena Gn.\*A. gamma (L.)=Plusia gamma L.

Common name: silver "Y" moth, gamma owlet

Hosts: P. vulgaris, Pisum sativum

References: Avidov and Harpaz 1969 p.343; Gane et al. 1971 p.VI-14; Rivnay 1962 p.125.

Autoserica castanea Arrow (Coleoptera: Scarabaeidae)

Common name: Asiatic garden beetle

Hosts: "beans"

References: Metcalf et al. 1962 p.606.

Azazia rubricans Boisd. (Lepidoptera: \*)

Common name: gram caterpillar

Hosts: Dolichos uniflorus

References: Purseglove 1968 p.264.

Bellicositermes natalensis (Hav.)see Macrotermes natalensis (Hav.)Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae)=B. gossypiperda Mis. & Lam.=B. inconspicua (Quaint.)Common name: tobacco, cotton, sweetpotato,  
or tomato whitefly

see page 75.

Bombus spp. (Hymenoptera: Bombidae)

Common name: bumble bee, humble bee

Hosts: P. coccineus

References: Wilson and Becker 1963 p.162.

Bruchidius chinensis (Thunberg)  
see Callosobruchus chinensis (L.)

B. atrolineatus Pic. (Coleoptera: Bruchidae)  
Common name: bean beetle, bean weevil  
Hosts: P. lunatus, Vigna unguiculata  
References: Tindall 1968 p.147,276.

B. quinqueguttatus Oliv.  
Common name: five-spotted weevil  
Hosts: Cicer arietinum, Vicia faba  
References: Avidov and Harpaz 1969 p.284.

Bruchus spp. (Coleoptera: Bruchidae)  
Common name: bean and pea weevils  
Hosts: all pulses  
References: Purseglove 1968 p.241,248,310,328.

B. affinis Frol.  
Common name: Spanish bean beetle  
Hosts: Vicia faba  
References: Wilson and Becker 1963 p.196.

B. brachialis (Fahraeus)  
Common name: vetch bruchid  
Hosts: Vicia faba  
References: Davidson and Peairs 1966 p.255.

B. dentipes Bdi.  
Hosts: Vicia faba  
References: Rivnay 1962 p.215.

B. ervi Frol.  
Common name: lentil weevil  
Hosts: Lens esculenta  
References: Avidov and Harpaz 1969 p.383; Rivnay 1962 p.215.

B. obtectus Say  
see Acanthoscelides obtectus (Say)

B. pisorum (L.)  
Common name: pea weevil  
Hosts: Pisum sativum  
References: Metcalf et al. 1962 p.935; Wilson and Becker 1963 p.196; Smit 1964 p.279; Rivnay 1962 p.212; National Research Council 1972 p.247,249; Davidson and Peairs 1966 p.275; Avidov and Harpaz 1969 p.281.

B. quadrinaculatus F.  
see Callosobruchus maculatus (F.)

B. rufimanus Boh.

Common name: broadbean weevil

Hosts: Vicia faba, Pisum sativum

References: Metcalf et al. 1962 p.936; Wilson and Becker 1963 p.196; Avidov and Harpaz 1969 p.283; Davidson and Peairs 1966 p.278; Rivnay 1962 p.215.

Cadra cautella (Walk.)

see Ephestia cautella (Walk.)\*

Caliothrips impurus (Pr.) (Thysanoptera: Thripidae)

=C. fumipennis (Bagn. & Cam.)

=Hercothrips fumipennis (Bagn. & Cam.)

Common name: dark cotton leaf thrips

Hosts: Arachis hypogaea, Lablab niger, P. vulgaris

References: Schmutterer 1969 p.46.

C. indicus (Bagn.)

=Heliothrips indicus Bagn.

Common name: cotton thrips

Hosts: Arachis hypogaea

References: Wyniger 1962 p.348.

C. sudanensis (Bagn. & Cam.)

Common name: grey cotton leaf thrips

Hosts: Arachis hypogaea, Lablab niger

References: Schmutterer 1969 p.48.

Callosobruchus spp. (Coleoptera: Bruchidae)

Common name: bean weevils

Hosts: all pulses

References: Tindall 1968 p.147,276; Purseglove 1968 p.310.

C. chinensis (L.)

=Bruchidius chinensis (Thunberg)

Common name: southern cowpea weevil, adzuki bean weevil, chinese weevil

Hosts: all pulses

References: ; Metcalf et al. 1962 p.937; Smit

1964 p.279; Davidson and Peairs 1966 p.279;

Avidov and Harpaz 1969 p.285; Rivnay 1962 p.215.

C. maculatus (F.)

=Bruchus quadrimaculatus F.

Common name: cowpea weevil

Hosts: all pulses

References: Metcalf et al. 1962 p.937,576; Schmutterer 1969

p.136; Avidov and Harpaz 1969 p.287; Davidson and Peairs

1966 p.278; Smit 1964 p.280; Rivnay 1962 p.215.

Carydon serratus (Oliv.) (Coleoptera: Bruchidae)= C. gonagra (F.)

Common name: peanut weevil

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.289.

Cerotoma denticola \* (Coleoptera: Chrysomelidae)Hosts: Glycine max

References: Senewiratne and Appadurai 1966 p.164.

C. ruficornis (Oliv.)

Common name: bean-leaf beetle

Hosts: Glycine max, Lablab niger, P. lunatus,  
Vigna unguiculata, "beans"References: Wyniger 1962 p.192; Purseglove 1968 p.328; Food  
and Agriculture Organization 1959 p.93,122.C. trifurcata (Forster)

Common name: bean leaf beetle

Hosts: Arachis hypogaea, Glycine max, P. lunatus,  
P. vulgaris, Pisum sativum, Vigna unguiculataReferences: Metcalf et al. 1962 p.624,576; National Research  
Council 1972 p.215; Davidson and Peairs 1966 p.281;Chalcodermus aeneus Boh. (Coleoptera: Cucurliionidae)

Common name: cowpea curculio

Hosts: P. lunatus, P. vulgaris, Vigna unguiculataReferences: Metcalf et al. 1962 p.576; Davidson and Peairs  
1966 p.251; Purseglove 1968 p.328.Chorizagrotis auxiliaris (Grote) (Lepidoptera: Noctuidae)

Common name: army cutworm

Hosts: all pulses

References: Metcalf et al. 1962 p.476.Chrotogonus sp. (Orthoptera: Acrididae)

Common name: grasshopper

Hosts: Arachis hypogaea

References: Wyniger 1962 p.347.

Cicadulina arachidis China\* (Homoptera: Cicadellidae)and C. similis China\*Hosts: Arachis hypogaea

References: Wyniger 1962 p.348.

C. zeae China= C. bipunctella (Matsumura)Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.69.

Cnephasia virgaureana (Treits.) (Lepidoptera: Tortricidae)

Common name: flat tortrix moth

Hosts: Pisum sativumReferences: Gane et al. 1971 p.VI-15.

Colaspis flavida (Say) (Coleoptera: Chrysomelidae)

Common name: grape colaspis, clover rootworm

Hosts: Glycine max, P. vulgaris, Vigna unguiculata, "beans"References: Metcalf et al. 1962 p.512, Wyniger 1962 p.188.Colias eurytheme Boisd. (Lepidoptera: Pieridae)

Common name: alfalfa caterpillar

Hosts: Arachis hypogaeaReferences: Wyniger 1962 p.345; Metcalf et al. 1962 p.555.Contarinia pisi L. (Diptera: Cecidomyiidae)

Common name: pea midge

Hosts: Pisum sativumReferences: Wilson and Becker 1963 p.198; Trought 1965 p.17; Gane et al. 1971 p.VI-16.Coptosoma cribraria F. (Hemiptera: Plataspidae)

Common name: stink bug

Hosts: Lablab niger

References: Purseglove 1968 p.276.

Coryna spp. (Coleoptera: Meloidae)

Common name: blossom beetles

Hosts: P. vulgaris, Vigna unguiculata

References: Acland 1972 p.113.

C. apicicornis Guer.\*Hosts: Arachis hypogaea

References: Wyniger 1962 p.351.

Corythuca gossypii F.\* (Hemiptera: Tingidae)

Common name: bean lace bug

Hosts: P. lunatus, P. vulgaris, "beans"

References: Wyniger 1962 p.195; Food and Agriculture Organization 1959 p.163.

Cosmolyce boetica (L.) (Lepidoptera: Lycaenidae)=Lampides boeticus (L.)=Lyceana boeticus (L.)

Common name: pea blue, blue copper butterfly

Hosts: Cajanus cajan, P. lunatus, P. vulgaris,Pisum sativum, Vicia faba, Vigna unguiculata

References: Avidov and Harpaz 1969 p.320; Talhouk 1969 p.26,199; Rivnay 1962 p.234; Senewiratne and Appadurai 1966 p.157.

Creontiades pallidus Ramb. (Hemiptera: Miridae)

Common name: shedder bug

Hosts: Arachis hypogaea

References: Wyniger 1962 p.343.



Delia cilicrura Rond.

see Hylemya cilicrura (Rond.)

Diabrotica undecimpunctata howardii Barber

(Coleoptera: Chrysomelidae)

Common name: spotted cucumber beetle, southern corn rootworm  
and D. undecimpunctata undecimpunctata Mannerheim

Common name: western spotted cucumber beetle

Hosts: Arachis hypogaea, "beans"

References: Metcalf et al. 1962 p.510,625,631;  
Woodroof 1973 p.77.

Diacrisia obliqua Walk. (Lepidoptera: Arctiidae)

Common name: common hairy caterpillar

Hosts: P. mungo, "beans"

References: Wyniger 1962 p.193; Purseglove 1968 p.304.

D. strigulata \*

see Spilosoma strigulata Walk.\*

D. virginica (F.)

Common name: yellow woollybear

Hosts: "beans"

References: Metcalf et al. 1962 p.611.

Dolichothrips varipes \* (Thysanoptera: \*)

Hosts: Cajanus cajan

References: Senewiratne and Appadurai 1966 p.157.

Dysmicoccus brevipes (Ckll.) (Homoptera: Pseudococcidae)

Common name: pineapple mealybug

Hosts: Arachis hypogaea

References: Wyniger 1962 p.220,344.

Ecpantheria albicornis Gn. (Lepidoptera: Arctiidae)

Hosts: "beans"

References: Wyniger 1962 p.197.

Elasmopalpus lignosellus (Zell.) (Lepidoptera: Pyralidae)

Common name: lesser cornstalk borer

Hosts: Arachis hypogaea, "beans"

References: Woodroof 1973 p.77; Wyniger 1962 p.190.

E. rubedinellus (Zell.)

Common name: pigeon pea worm

Hosts: Cajanus cajan

References: Tindall 1968 p.209,278; Purseglove 1968 p.241.

Empoasca decedens (Paoli) (Homoptera: Cicadellidae)

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.68.

- E. decipiens (Paoli)  
 Hosts: P. vulgaris, Vigna unguiculata  
 References: Avidov and Harpaz 1969 p.67.
- E. fabae (Harris)  
 Common name: potato leafhopper  
 Hosts: Arachis hypogaea, Glycine max, P. vulgaris,  
Vigna unguiculata, "beans"  
 References: Metcalf et al. 1962 p.643; Davidson and Peairs  
 1966 p.256; Wyniger 1962 p.347; Zaumeyer and Thomas 1957  
 p.127.
- E. fabalis Delong\*  
 Common name: bean leafhopper  
 Hosts: "beans"  
 References: Wyniger 1962 p.195.
- E. facialis (Jac.)  
 Common name: cotton jassid  
 Hosts: Arachis hypogaea  
 References: Schmutterer 1969 p.77; Wyniger 1962 p.349; Smit  
 1964 p.140.
- Ephestia sp. (Lepidoptera: Pyralidae)  
 Common name: stored grain moth  
 Hosts: Glycine max  
 References: Senewiratne and Appadurai 1966 p.164.
- E. cautella (Walk.)\*  
 =Cadra cautella (Walk.)  
 Common name: almond moth  
 Hosts: Arachis hypogaea  
 References: Avidov and Harpaz 1969 p.361.
- Epicauta spp. (Coleoptera: Meloidae)  
 Common name: blister beetle  
 Hosts: Glycine max  
 References: Purseglove 1968 p.271.
- E. aethiops (Latr.)  
 Common name: grey blister beetle  
 Hosts: Lablab niger, Vigna unguiculata  
 References: Schmutterer 1969 p.130.
- E. vittata F.  
 Common name: striped blister beetle  
 Hosts: Glycine max, P. vulgaris, Pisum sativum,  
Vigna unguiculata  
 References: Metcalf et al. 1962 p.576,642;  
 Wyniger 1962 p.191.

Epilachna varivestis Muls. (Coleoptera: Coccinellidae)=E. corrupta Muls.

Common name: Mexican bean beetle

Hosts: Glycine max, P. lunatus, P. vulgaris,  
Vigna unguiculata, "beans"References: Metcalf et al. 1962 p.576,622; Davidson and Peairs 1966 p.280; National Research Council 1972 p.215,238; Ware and McCollum 1968 p.239,519; Wyniger 1962 p.192.Eremotermes nanus Harr. (Isoptera: Termitidae)

Common name: termite

Hosts: Arachis hypogaea

References: Schmutterer 1969 p.42.

Erythroneura sp. (Homoptera: Cicadellidae)=Typhlocyba sp.

Hosts: "beans"

References: Wyniger 1962 p.195.

E. coacta Ribaut

Common name: Cyprus corn leafhopper

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.68.

E. lubiae ChinaHosts: Arachis hypogaea, Lablab niger, P. vulgaris,  
Vigna unguiculata

References: Schmutterer 1969 p.77.

E. pallidifrons Edw.

Common name: glasshouse leafhopper

Hosts: P. vulgaris

References: Wilson and Becker 1963 p.108.

Estigmene acrea (Drury) (Lepidoptera: Arctiidae)

Common name: salt-marsh caterpillar

Hosts: "beans"

References: Metcalf et al. 1962 p.611.Etiella zinkenella (Treit.) (Lepidoptera: Pyralidae)

Common name: lima bean pod borer, legume pod moth

Hosts: Cajanus cajan, Glycine max, Lablab niger, P. lunatus,  
P. vulgaris, Pisum sativum, Vicia fabaReferences: Schmutterer 1969 p.154; Metcalf et al. 1962 p.622; Avidov and Harpaz 1969 p.366; Davidson and Peairs 1966 p.271; Wyniger 1962 p.197; Rivnay 1962 p.237.Euschistus servus \* (Hemiptera: Pentatomidae)

Common name: brown stink bug

Hosts: Glycine max

References: National Research Council 1972 p.215.

Exelastis atomosa W. (Lepidoptera: \*)Hosts: Cajanus cajan

References: Purseglove 1968 p.240.

Frankliniella fusca (Hinds.) (Thysanoptera: Thripidae)

Common name: tobacco thrips

Hosts: Arachis hypogaea

Wyniger 1962 p.350.

F. robusta \*see Kakothrips robustus (Uzel)F. tritici (Fitch)

Common name: common flower thrips

Hosts: Arachis hypogaea

References: Wyniger 1962 p.350.

Fundella cistipennis Dyar,\* (Lepidoptera: Pyralidae)

Common name: bean pod borer

Hosts: P. lunatus

References: Wyniger 1962 p.196.

Gnapolitha nigricana \*see L. nigricana (Stephens)\*Graphognathus leucoloma (Boh.) (Coleoptera: Curculionidae)=Pontomorus leucoloma \*

Common name: white-fringed weevil or beetle

Hosts: Arachis hypogaea, Glycine max, Vigna unguiculataReferences: Metcalf et al. 1962 p.576,607; Wyniger  
1962 p.342; Purseglove 1968 p.233.Halticus bracteatus (Say) \*

Common name: garden fleahopper

Hosts: P. vulgaris, Pisum sativum, Vigna unguiculata,  
"beans"

References: Metcalf et al. 1962 p.615.

Heliothis armigera (Hubner) (Lepidoptera: Noctuidae)=H. obsoleta F.=Helicoverpa armigera (Hubner).

see page 87.

H. peltigera (Schiff.)Hosts: Arachis hypogaea

References: Schmutterer 1969 p.188.

H. virescens (F.)

Common name: tobacco budworm

Hosts: Cajanus cajan

References: Purseglove 1968 p.241.

H. zea (Boddie)= H. armigera (Hubner) [in part]Common name: corn earworm, cotton bollworm,  
tomato fruitworm

Hosts: "beans"

References: Davidson and Peairs 1966 p.158;  
Metcalf et al. 1962 p.498.Heliothrips indicus Bagn.see Calliothrips indicus (Bagn.)Hercothrips fasciatus (Perg.) (Thysanoptera: Thripidae)

Common name: bean thrips

Hosts: "beans"

References: Metcalf et al. 1962 p.578,621,742;  
Wyniger 1962 p.194.Hercothrips fumipennis (Bagn. & Cam.)see Calliothrips impurus (Pr.)Herse convolvuli (L.) (Lepidoptera: Sphingidae)= Sphinx convolvuli L.

Common name: convolvulus hawk moth

Hosts: "beans"

References: Rivnay 1962 p.339.

Hilda patruellis Stal.\* (Homoptera: Tettigometridae)

Common name: groundnut hopper

Hosts: Arachis hypogaeaReferences: Acland 1972 p.122; Wheatley 1965 p.15;  
Wyniger 1962 p.344.Hodotermes mossambicus Hag. (Isoptera: Hodotermitidae)

Common name: termite

Hosts: Arachis hypogaea, "beans"References: Wyniger 1962 p.188,342,383,457; Acland 1972  
p.122; Smit 1964 p.91.Hofmannophila pseudospretella Staint. (Lepidoptera: \*)

Common name: brown house moth

Hosts: Pisum sativum, "beans"

References: Wilson and Becker 1963 p.201.

Hylabris temporalis \* (Coleoptera: \*)Hosts: Vigna unguiculata

References: Tindall 1965 p.239.

Hylemya cilicrura (Rond.) (Diptera: Anthomyiidae)= H. platura (Meig.)= Delia cilicrura Rond.

Common name: seed-corn maggot, bean seed fly

Hosts: Arachis hypogaea, Glycine max, P. vulgaris,  
Pisum sativum, "beans"

References: Metcalf et al. 1962 p.518,622; Zaumeyer and Thomas 1957 p.129; Avidov and Harpaz 1969 p.451; Rivnay 1962 p.131; National Research Council 1972 p.215; Commonwealth Institute of Entomology 1962; Trought 1965 p.20; Wilson and Becker 1963 p.88,199.

Hypera meles (F.) (Coleoptera: Curculionidae)

Common name: clover head weevil

Hosts: "beans"

References: Davidson and Peairs 1966 p.248.

H. punctata (F.)

Common name: clover leaf weevil

Hosts: Glycine max, P. vulgaris

References: Davidson and Peairs 1966 p.246.

H. sububvittata (Cap.)

Hosts: Pisum sativum, Vigna unguiculata

References: Avidov and Harpaz 1969 p.297;

Talhouk 1969 p.26,142.

Icerya purchasi Mask. (Homoptera: Coccidae)

Common name: cottony cushion scale

Hosts: Cajanus cajan

References: Food and Agriculture Organization, 1959 p.45.

Isia isabella (J. E. Smith) (Lepidoptera: Arctiidae)

Common name: banded woollybear

Hosts: "beans"

References: Metcalf et al. 1962 p.611.

Kakothrips robustus (Uzel) (Thysanoptera: Thripidae)

=Frankliniella robusta \*

Common name: pea thrips

Hosts: Pisum sativum, Vicia faba

References: Wilson and Becker 1963 p.163,173;

Gane et al. 1971 p.VI-16; Trought 1965 p.18.

Lachnosterna jamaicensis \* (Coleoptera: Scarabaeidae)

Hosts: Cajanus cajan

References: Food and Agriculture Organization 1959 p.56.

Lagria cuprina \* (Coleoptera: Lagridae)

Hosts: Vigna unguiculata

References: Tindall 1965 p.239.

L. villosa (F.)

Hosts: Glycine max

References: Tindall 1965 p.55.

Lampides boeticus (L.)

see Cosmolyce boetica (L.)

Lampides icarus \*see Polyommatus icarus lucia Cul.\*Lamprosema indicata F.\* (Lepidoptera: Pyralidae)

Common name: leaf eater moth, leaf folder

Hosts: Glycine max, P. lunatus, P. vulgaris, "beans"

References: Wyniger 1962 p.196,346; Senewiratne and Appadurai 1966 p.164; Food and Agriculture Organization 1959 p.163.

Laphygma exigua Hubn.see Spodoptera exigua (Hubn.)Laphygma frugiperda (J.E. Smith)see S. frugiperda (J.E. Smith)Laspeyresia dorsana (F.) (Lepidoptera: Tortricidae)Hosts: Pisum sativum

References: Avidov and Harpaz 1969 p.388; Rivnay 1962 p.236.

L. glycinovorella Mats.

Common name: soybean pod borer, soybean moth

Hosts: Glycine max

References: Wyniger 1962 p.197; Purseglove 1968 p.271.

L. nigricana (Stephens)=Gnapolitha nigricana \*

Common name: pea moth

Hosts: Pisum sativum

References: Gane et al. 1971 p.VI-12; Davidson and Peairs 1966 p.274; Talhouk 1969 p.26,174; Metcalf et al. 1962 p.627; Trought 1965 p.15.

Leptoglossus phyllopus (L.) (Hemiptera: Coreidae)

Common name: leaf-footed bug

Hosts: P. vulgaris, Vigna unguiculata, "beans"

References: Davidson and Peairs 1966 p.271.

Liriomyza spp. (Diptera: Agromyzidae)

Common name: leaf miners

Hosts: "beans"

References: Spencer 1973 p.97,153,214,215,226.

L. cicerina (Rond.)Hosts: Cicer arietinum

References: Spencer 1973 p.90.

L. congesta (Beck.)

Common name: pea leaf miner

Hosts: Cicer arietinum, Pisum sativum

References: Gane et al. 1971 p.VI-15; Rivnay 1962 p.239.

L. sativae Blanchard

= L. munda Frick

Hosts: Cicer arietinum, P. lunatus, P. vulgaris,  
Vigna unguiculata

References: Spencer 1973 p.219.

Locusta spp. (Orthoptera: Acrididae)

References: Metcalf et al. 1962 p.465.

L. migratoria migratoriodes (Reiche & Fair.)

Common name: African migratory locust

Hosts: "beans"

References: Wyniger 1962 p.448.

Locustana pardalina Walk. (Orthoptera: Acrididae)

Common name: brown locust

Hosts: "beans"

References: Wyniger 1962 p.448; Smit 1964 p.63.

Luperodes quaternus Fairm. (Coleoptera: Chrysomilidae)

Hosts: Arachis hypogaea, Lablab niger

References: Schmutterer 1969 p.134; Wyniger 1962 p.344.

Lyceana boeticus (L.)

see Cosmolyce boetica (L.)

Lycophotia saucia \*

see Peridroma saucia (Hubn.)

Lygus elisus Van Duzee (Hemiptera: Miridae)

and L. hesperus Knight

Common name: lygus bug

Hosts: P. lunatus

References: Zaumeyer and Thomas 1957 p.156.

L. lineolaris P. de B.

Common name: tarnished plant bug

Hosts: Glycine max

References: National Research Council 1972 p.215.

L. pabulinus L.

Common name: common green capsid bug

Hosts: "beans"

References: Wilson and Becker 1963 p.153.

L. vosseleri (Popp.)

see Taylorilygus vosseleri (Popp.)

Macrosiphum pisi (Kalt.)

and M. pisum (Harris)

see Acyrtosiphon pisum (Harris)



Macrotermes bellicosus (Smeath.) (Isoptera: Termitidae)

Common name: war-like termite

Hosts: Arachis hypogaea

References: Schmutterer 1969 p.38.

M. natalensis (Hav.)=Bellicositermes natalensis (Hav.)Hosts: Arachis hypogaea

References: Schmutterer 1969 p.4.

Marseulia dilativentris Reiche (Coleoptera: Chrysomelidae)

Common name: cereal leaf beetle

Hosts: P. vulgaris, Pisum sativum, Vicia faba

References: Avidov and Harpaz 1969 p.276.

Maruca testulatis (Gey.) (Lepidoptera: Pyralidae)

Common name: spotted pod borer, mung moth

Hosts: Arachis hypogaea, Cajanus cajan, P. vulgaris,  
Vicia faba, Vigna unguiculata, "beans"References: Acland 1972 p.23,113; Wyniger 1962 p.197,346;  
Schmutterer 1969 p.161; Senewiratne and Appadurai 1966  
p.157.Megacoelum modestum Dist. (Hemiptera: Miridae)

Hosts: "beans"

References: Wyniger 1962 p.198.

Melanagromyza spp. (Diptera: Agromyzidae)

Common name: bean flies

Hosts: "beans"

References: Spencer 1973 p.32,34,37,44,50,52.

M. obtusa (Malloch)

Common name: seed maggot, red gram pod borer

Hosts: Cajanus cajan, P. mungo, "beans"References: Spencer 1973 p.46; Senewiratne and Appadurai  
1966 p.157; Pradhan 1969 p.71.M. phaseoli (Tryon)see Ophiomyia phaseoli (Tryon)Microtermes thoracalis Sjost. (Isoptera: Termitidae)

Common name: cotton soil termite

Hosts: Arachis hypogaea, Lablab niger

References: Schmutterer 1969 p.39.

Monolepta australis Jac. (Coleoptera: Chrysomelidae)

Common name: red shouldered leaf beetle

Hosts: Arachis hypogaea

References: Wyniger 1962 p.350.

Monoptilota pergratialis (Hulst) \*

Common name: lima bean vine borer

Hosts: P. lunatus

References: Davidson and Peairs 1966 p.271.

Mylabris oculata \* (Coleoptera: Meloidae)Common name: C.M.R. beetle, bean flower beetle,  
blister beetle

Hosts: "beans"

References: Smit 1964 p.240; de Pury 1968 p.159.

M. pustulata \*

Common name: flower eating beetle

Hosts: Cajanus cajan

References: Senewiratne and Appadurai 1966 p.157.

Myllocerus sp. (Coleoptera: Curculionidae)Hosts: Arachis hypogaea

References: Wyniger 1962 p.345.

Nematocerus sp. (Coleoptera: Curculionidae)

Common name: shiny cereal weevil, legless grub

Hosts: "beans"

References: de Pury 1968 p.140.

Nezara viridula (L.) (Hemiptera: Pentatomidae)= N. hilaris (L.)

Common name: southern green stinkbug, green plant bug

Hosts: P. lunatus, Vigna unguiculata, "beans"

References: Schmutterer 1969 p.54; Wyniger 1962 p.190,363;

Smit 1964 p.135; Zaumeyer and Thomas 1957 p.157; Rivnay

1962 p.49; Commonwealth Institute of Entomology 1970.

Nomadacris septemfasciata Serv. (Orthoptera: Acrididae)

Common name: red locust

Hosts: "beans"

References: Wyniger 1962 p.449; Smit 1964 p.68.

Ophiomyia spp. (Diptera: Agromyzidae)

Common name: bean flies

Hosts: "beans"

References: Spencer 1973 p.56,59,68,70.

O. phaseoli (Tryon)= Agromyza phaseoli Coq.= Melanagromyza phaseoli (Tryon)Common name: bean fly, snap bean fly, bean stem maggot  
see page 96.Oxycetonia versicolor F. (Coleoptera: Scarabaeidae)

Common name: flower beetle

Hosts: Arachis hypogaea

References: Wyniger 1962 p.351.

Pagria signata Motsch. (Coleoptera: Chrysomelidae)Hosts: Glycine max

References: Wyniger 1962 p.187.

Pergandeida robiniae Macch.\* (Homoptera: Aphididae)Hosts: Arachis hypogaea

References: Wyniger 1962 p.349.

Peridroma saucia (Hubn.) (Lepidoptera: Noctuidae)=Lycophotia saucia \*

Common name: variegated cutworm

Hosts: "beans"

References: Wyniger 1962 p.198.

Phyllophaga spp. (Coleoptera: Scarabaeidae)

Common name: May beetle, June beetle, white grub

Hosts: Arachis hypogaea

References: Woodroof 1973 p.76.

Phyllotreta cruciferae Goeze (Coleoptera: Chrysomelidae)=P. columbiana Chitt.

Common name: cabbage flea beetle

Hosts: P. vulgaris

References: Avidov and Harpaz 1969 p.278.

Phymateus leprosus (F.) (Orthoptera: Pyrgomorphidae)

Common name: bush locust, bush grasshopper

Hosts: "beans"

References: Smit 1964 p.71.

Physomerus grossipes F. (Hemiptera: Coreidae)

Hosts: "beans"

References: Wyniger 1962 p.190,214.

Phytometra chalcites Esp.\*see Plusia chalcites (Esp.)Phytomyza atricornis Meig. (Diptera: Agromyzidae)=P. horticola Gour. (in part)

Common name: chrysanthemum leaf miner

Hosts: Pisum sativum, Vicia faba

References: Spencer 1973 p.205; Wilson and Becker 1963 p.148; Avidov and Harpaz 1969 p.430; Rivnay 1962 p.238; Pradhan 1969 p.71; Commonwealth Institute of Entomology 1965.

P. horticola Gour.

Common name: pea leaf miner

Hosts: Cicer arietinum, Lens esculenta, Pisum sativum,  
Vicia faba, Vigna unguiculataReferences: Spencer 1973 p.229; Gane et al. 1971 p.VI-15.

Phytonomus nigrirostris F. (Coleoptera: Cucurlionidae)

Hosts: "beans"

References: Wyniger 1962 p.189.

Plagioderma inclusa Stal. (Coleoptera: Chrysomelidae)

Common name: soybean leaf beetle

Hosts: Glycine max

References: Frohlich and Rodewald 1970 p.216.

Planococcus citri (Risso) (Homoptera: Pseudococcidae)

Common name: citrus mealybug

Hosts: Arachis hypogaea

References: Avidov and Harpaz 1969 p.176.

Plathypena scabra (F.) (Lepidoptera: Noctuidae)

Common name: green clover worm

Hosts: Glycine max, P. vulgaris, Vigna unguiculata

References: Davidson and Peairs 1966 p.266; National Research Council 1972 p.215; Metcalf et al. 1962 p.556.

Plusia chalcites (Esp.) (Lepidoptera: Noctuidae)= Autographa chalcites \*= Phytometra chalcites Esp.\*Hosts: P. vulgaris

References: Avidov and Harpaz 1969 p.345; Rivnay 1962 p.130.

P. egena \*see Syngrapha egena Gn.\*P. gamma L.see Autographa gamma (L.)Podagrica uniforma (Jac.) (Coleoptera: Chrysomelidae)

Common name: flea beetle

Hosts: P. vulgaris, Vigna unguiculata

References: Tindall 1965 p.55,239.

Polyommatus icarus lucia Cul.\* (Lepidoptera: Lycaenidae)= Lampides icarus \*Hosts: Vigna unguiculata

References: Rivnay 1962 p.235.

Pontomorus leucoloma \*see Graphognathus leucoloma (Boh.)Popillia japonica Newman (Coleoptera: Scarabaeidae)

Common name: Japanese beetle

Hosts: Glycine maxReferences: Ware and McCollum 1968 p.519;  
Metcalf et al. 1962 p.749.

Prodenia litura F.see Spodoptera litura (F.)Pseudoplusia includens (Walk.) (Lepidoptera: Noctuidae)=Pseudophisia [sic] includens (Walk.)

Common name: soybean looper

Hosts: Glycine max

References: National Research Council 1972 p.215.

Ptinus tectus Boield. (Coleoptera: Ptinidae)=P. ocellus Brown

Common name: Australian spider beetle

Hosts: Pisum sativum, "beans"

References: Wilson and Becker 1963 p.201.

Rhadidopalpa foveicollis Luc. (Coleoptera: Chrysomelidae)

Common name: red pumpkin beetle

Hosts: P. vulgaris

References: Avidov and Harpaz 1969 p.275.

Rhizopertha dominica (F.) (Coleoptera: Bostrychidae)

Common name: lesser grain borer

Hosts: P. vulgaris, "beans"

References: Avidov and Harpaz 1969 p.248.

Sagra sp. (Coleoptera: Chrysomelidae)

Common name: stem-boring beetles

Hosts: Canavalia ensiformis

References: Tindall 1968 p.117,275.

Schistocerca americana (Dru.) (Orthoptera: Acrididae)=S. paranensis (Burm.)

Hosts: "beans"

References: Wyniger 1962 p.448.

S. gregaria (Forsk.)

Common name: desert locust

Hosts: "beans"

References: Smit 1964 p.70; Wyniger 1962 p.447.

Schizonycha africana Cast. (Coleoptera: Scarabaeidae)

Common name: cockchafer

Hosts: Arachis hypogaea

References: Wyniger 1962 p.341.

S. cibrata BlanchHosts: Lablab niger

References: Schmutterer 1969 p.125; de Pury 1968 p.139.

Scirtothrips dorsalis Hood\* (Thysanoptera: Terebrantia)

Common name: thrips

Hosts: Arachis hypogaea

References: Wyniger 1962 p.347,384.

Sitona spp. (Coleoptera: Curculionidae)

Common name: pea weevil, bean weevil

Hosts: Pisum sativum, Vicia fabaReferences: Gane et al. 1971 p.VI-9; Wilson and Becker 1963 p.134; Trought 1965 p.14.S. limosa Rossi

Common name: leaf weevil

Hosts: Vicia faba

References: Avidov and Harpaz 1969 p.291; Food and Agriculture Organization 1959 p.286.

S. lineata L.

Common name: bean and pea leaf weevil

Hosts: Pisum sativum, Vicia fabaReferences: Wilson and Becker 1963 p.143; Avidov and Harpaz 1969 p.291; Talhouk 1969 p.136; Rivnay 1962 p.216; Gram et al. 1969 p.46.Sminthurus viridis L. (Collembola: Sminthuridae)=Smynthurus [sic] viridis L.

Common name: lucern springtail

Hosts: P. sativum, "beans"

References: Food and Agriculture Organization 1957 p.253,254,257; Rivnay 1962 p.206.

Smynthurodes betae Westw. (Collembola: Sminthuridae)

Common name: root aphid

Hosts: P. vulgaris, Vicia faba

References: Wilson and Becker 1963 p.45.

Sphenarches caffer \* (Lepidoptera: Pterophoridae)

Common name: plume moth

Hosts: Cajanus cajan

References: Senewiratne and Appadurai 1966 p.157.

Sphenoptera perotetti G. (Coleoptera: Buprestidae)Hosts: Arachis hypogaea

References: Wyniger 1962 p.343; Purseglove 1968 p.233.

Sphinx convolvuli L.see Herse convolvuli (L.)Spilosoma strigulata Walk.\* (Lepidoptera: Arctiidae)=Diaerisia strigulata \*Hosts: Arachis hypogaea

References: Wyniger 1962 p.344.

Spissitilus festinus (Say) (Homoptera: Membracidae)

Common name: three-cornered alfalfa hopper

Hosts: Vigna unguiculata, "beans"

References: Davidson and Peairs 1966 p.270.

Spodoptera exigua (Hubn.) (Lepidoptera: Noctuidae)= Laphygma exigua Hubn.

Common name: beet armyworm, lesser armyworm

Hosts: Arachis hypogaea, Pisum sativum, Vigna unguiculata,  
"beans"References: Smit 1964 p.219; de Pury 1968 p.107; Wyniger  
1962 p.346,409; Metcalf et al. 1962 p.610; Avidov and  
Harpaz 1969 p.332; Schmutterer 1969 p.185; Talhouk 1969  
p.26,190.S. frugiperda (J.E. Smith)= Laphygma frugiperda (J.E. Smith)

Common name: fall armyworm

Hosts: Arachis hypogaea, "beans"References: Woodroof 1973 p.78; Metcalf et al. 1962 p.473;  
Food and Agriculture Organization 1959 p.69; Commonwealth  
Institute of Entomology 1956.S. littoralis (Boisd.)

Common name: Egyptian cotton leaf worm, cotton worm

Hosts: Arachis hypogaea, Glycine max, P. vulgaris,  
Vigna unguiculata, "beans"References: Schmutterer 1969 p.186; Avidov and Harpaz 1969  
p.327; de Pury 1968 p.107; Tindall 1965 p.55.S. litura (F.)= Prodenia litura F.

Common name: cotton worm

Hosts: Arachis hypogaea, "beans"References: Wyniger 1962 p.194,347,423; Rivnay 1962  
p.102,387; Talhouk 1969 p.26,188; Commonwealth  
Commonwealth Institute of Entomology 1967.Stomopteryx nerteria Meyr. (Lepidoptera: Gelechiidae)

Common name: leaf roller moth

Hosts: Arachis hypogaeaReferences: Senewiratne and Appadurai 1966 p.357; Purseglove  
1968 p.233.S. subsecivella Zell.\*

Common name: groundnut surul

Hosts: Arachis hypogaea

References: Wyniger 1962 p.345.

Syngnapha egena Gn.\* (Lepidoptera: Noctuidae)= Plusia egena \*= Autographa egena \*

Hosts: "beans"

References: Wyniger 1962 p.198.

Systates spp. (Coleoptera: Curculionidae)

Common name: weevil

Hosts: Arachis hypogaea

References: Acland 1972 p.122.

Taeniothrips distalis Karny\* (Thysanoptera: Thripidae)

Common name: thrips

Hosts: Arachis hypogaea

References: Wyniger 1962 p.348.

Taylorilygus vosseleri (Popp.) (Hemiptera: Miridae)=Lygus vosseleri (Popp.)Hosts: Vigna unguiculata

References: Schmutterer 1969 p.63.

Thosea unguiculata Walk.\* (Lepidoptera: Limacodidae)

Hosts: "beans"

References: Wyniger 1962 p.193.

Thrips spp. (Thysanoptera: Thripidae)

Common name: thrips

Hosts: Arachis hypogaea, Pisum sativum, Vicia faba,  
Vigna unguiculataReferences: Wilson and Becker 1963 p.107; Woodroof 1973  
p.77; Acland 1972 p.113.T. angusticeps (Uzel)\*

Common name: cabbage thrips

Hosts: Pisum sativum

References: Gane et al. 1971 p.VI-8.

T. tabaci Lindeman

Common name: onion thrips

Hosts: Arachis hypogaea, P. vulgaris, Pisum sativum, "beans"References: Avidov and Harpaz 1969 p.49; National Research  
Council 1972 p.238; de Pury 1968 p.42; Rivnay 1962 p.74,  
387; Commonwealth Institute of Entomology 1969.Tipula spp. (Diptera: Tipulidae)

Common name: crane fly, leatherjacket

Hosts: Pisum sativum

References: Gane et al. 1971 p.V-I4.

Trichoplusia ni (Hubn.) (Lepidoptera: Noctuidae)

Common name: cabbage looper

Hosts: P. vulgarisReferences: Avidov and Harpaz 1969 p.345;  
Talhouk 1969 p.195.Triphaena pronuba (L.) (Lepidoptera: Noctuidae)=Agrotis pronuba

Common name: large yellow underwing

Hosts: Vicia faba

References: Avidov and Harpaz 1969 p.336.



Typhlocyba sp.  
see Erythroneura sp.

Urentius euonymus Dist. (Hemiptera: Tingidae)

Common name: lace bug

Hosts: Cajanus cajan

References: Schmutterer 1969 p.59.

Utetheisa lotrix (Cram.) (Lepidoptera: Arctiidae)

Hosts: Cajanus cajan

References: Schmutterer 1969 p.168.

Valanga nigricornis Burm.\* (Orthoptera: Acrididae)

Common name: grasshopper

Hosts: "beans"

References: Wyniger 1962 p.194.

Virachola sp. (Lepidoptera: Lycaenidae)

Common name: bean butterfly

Hosts: Pisum sativum, "beans"

References: de Pury 1968 p.126.

Zabrotes subfasciatus Boh. (Coleoptera: Bruchidae)

Common name: Brazil bean weevil

Hosts: Cicer arietinum, Pisum sativum, "beans"

References: Frohlich and Rodewald 1970 p.320.

Zonocerus elegans (Thunb.) (Orthoptera: Acrididae)

Common name: elegant grasshopper

Hosts: "beans"

References: Smit 1964 p.73.

## b) Other Arthropods

Armadillidium vulgare (Latr.) (Isopoda: Armadillididae)

=A. nasatum B.-L.

=Oniscus asellus L.

Common name: pillbug, woodlouse

Hosts: P. vulgaris, "beans"

References: Metcalf et al. p.883; Wilson and Becker 1963 p.132.

Julus spp. (Diplopoda: Julidae)

also Blaniulus guttalatus (Bosc.) and

Orthomorpha gracilis Koch

Common name: millipede

Hosts: Arachis hypogaea, Pisum sativum, "beans"

References: Metcalf et al. 1962 p.620,884; Gane et al. 1971 p.VI-6; Schmutterer 1969 p.14; Wilson and Becker 1963 p.199; Sevey 1915 p.40.

Halotydeus destructor (Tucker) (Acari: Eupodidae)

Hosts: Pisum sativum

References: Food and Agriculture Organization 1959 p.252,253,257.

Tetranychus cinnabarinus (Boisd.) (Acarina: Tetranychidae)

and T. urticae Koch

=T. telarius (L.)

Common name: common red spider mite, two-spotted mite, glasshouse red spider mite

Hosts: Arachis hypogaea, P. vulgaris, Vicia faba, "beans"

References: Metcalf et al. 1962 p.616; Wilson and Becker 1963 p.106; Wyniger 1962 p.196,350,415; Smit 1964 p.43 Rivnay 1962 p.68; Talhouk 1969 p.26,63; National Research Council 1972 p.238; Avidov and Harpaz 1969 p.9.

### 3. THREE REPRESENTATIVE INSECT PESTS

#### a) Criteria for Selection

Three important pests of pulse crops were selected for detailed study. The criteria for inclusion were (1) that the pest has a wide geographical range of infestation, (2) causes serious economic damage to pulse production, and (3) is representative of other pest species. For example, the whitefly Bemisia tabaci is representative of other virus-vectoring homopterans and the seed pod-boring Heliothis armigera fills a niche similar to other pod borers, such as Maruca testulatis or Etiella zinkenella.

Although not all types of pests are considered, examples of several of the most damaging types of insects are provided. These insects are primarily a problem in the warmer parts of the world where pulses often fill a large part of the protein requirements of the population. The information on taxonomy, damage, biology and population regulation is purposefully slanted toward the type of knowledge required by a pest manager. In most cases, the selected references are sources of information readily accessible through a library system.

In any particular area the local agricultural advisory publications are the best source of current control recommendations. The control methods mentioned here are not recommended for any specific location, but are rather

indications of methods commonly used in some areas. This accounts for the mention of several persistent pesticides that are generally no longer allowed in some industrialized countries, but that are still a mainstay of pest control programs in much of the world.

The three insects discussed in the following section are: Bemisia tabaci, a virus-vectoring whitefly; Heliothis armigera, a pod-boring caterpillar; and Ophiomyia (=Melanagromyza) phaseoli, a stem-boring maggot.

b) Review of Taxonomy, Damage, Biology,  
and Population Regulation

Bemisia tabaci (Genn.) (Homoptera: Aleyrodidae)

=B. inconspicua (Quaint.)

=B. gossypiperda Mis. & Lam.

tobacco, cotton, sweetpotato, or tomato whitefly

Taxonomy

The identification of whiteflies is difficult due to a lack of characteristics that clearly differentiate between species and sometimes between genera. Most adult whiteflies are very similar and do not provide adequate criteria for identification

(El-Helaly et al. 1971a). Certain stages of the nymphs and "pupae" have definable taxonomic characteristics after special preparation for microscopic examination. A key to seven genera of whiteflies commonly found in Egypt (Habib and Farag, 1971) is one of few such keys available. It may be of some use in other parts of the tropics and sub-tropics. Thorough descriptions of the instars of Bemisia tabaci are also provided.

The structure of the waxy filaments covering the nymphs can vary greatly intraspecifically in whiteflies, causing confusion in their identification. Mound (1963) determined that the waxy structures are differently influenced by variation in the micro-topography of the host species' leaf surface.

#### Damage

Injury to crops by "sucking" insects can be one of the most difficult types of damage to measure and control. This is due not only to the physical loss of nutrients by the plant, but also to the common phenomena of phytotoxic salivary secretions and of virus or mycoplasma disease transmission.

Aphids and leafhoppers are well known for their role in reducing crop productivity by these methods. A less-studied group, also within the order Homoptera, are the whiteflies (Aleyrodidae). In temperate regions whiteflies are common pests of greenhouses and some horticultural crops. In the tropics, however, their sensitivity to cold is not such a limiting factor

so they are more important as causes of plant damage. Bemisia tabaci plays a role among whiteflies somewhat analogous to that of Myzus persicae (Sulzer) among the aphids. Both are vectors of many plant diseases and have large host ranges. B. tabaci has been recorded feeding on at least 172 plant species in 34 families (Azab et al. 1970) and it transmits over 25 diseases throughout its pan-tropical range (Varma 1963).

Much of the earlier work on B. tabaci concerned its damage to cotton in the southeastern Mediterranean region, although it is also considered a pest of many crops throughout the tropics and subtropics. The economic significance of this whitefly has been realized only in the past few decades. Beginning in the mid-1950's it was considered an important pest on Egyptian cotton (Azab et al. 1971) and proof of its role as a vector of viruses has been available only since the mid 1940's (Costa 1969). There is relatively little known about the plant diseases this insect vectors.

The effect of B. tabaci on pulse crops is not thoroughly documented. Twenty-nine legume species are recorded as hosts, more than any other botanical family (Azab et al. 1970). Most pulses would seem to be potential hosts. The greatest damage to pulses is likely to result from vectored viruses, although under conditions favorable to population build-ups the physical impact of nutrient loss and necrotic or chlorotic puncture spots from masses of whiteflies can lead to wilting (Avidov and Harpaz 1969; Smit 1964).

## Biology

Copulation takes place on the host leaf one hour to three days after emergence of the adult. This and all life stages of B. tabaci are temperature-dependent and so the period of time needed for any part of the 225 degree-day life cycle depends on climate and season (Avidov and Harpaz 1969).

Oviposition begins one to six days after copulation in summer and usually after less than 22 days in winter. The small, oval, 0.1-mm eggs are laid scattered or roughly clumped, mostly on the ventral surface of the host plant's upper leaves (Azab et al. 1971). The eggs are "hung" by a pedicel (0.03 mm) that is anchored in the mesophyll. The pedicel appears to keep the egg moist by transmission of moisture from the leaf, thereby overcoming the lethal effects of desiccation.

The potential fecundity of this insect is indicated by experiments carried out by Avidov and Harpaz (1969) in Israel. Laboratory cultures at summer temperatures increased their numbers 50-fold for each of seven generations. During warm weather (27°C is optimum) the life cycle required only two weeks. Azab et al. (1971) reported that caged females oviposit a mean of 161 eggs. Parthenogenesis occurred, but the offspring of unfertilized eggs were all male. They found the sex ratio during the cooler season was weighted towards the females (1:2 to 1:5.75) and during the summer was approximately even.

The eggs hatch after a few days to a few weeks and "crawler" first instar nymphs emerge to wander about the plant

for several hours. The crawler attaches itself with its stylet to a suitable site on the underside of a leaf, often on a part of the plant lower than where the eggs were laid. The insect will not move from this position until it emerges as an adult (Avidov and Harpaz 1969).

The nymph passes through three molts. Each time it loses insect-like body characteristics until it molts to the fourth instar: a yellow, flattened ovoid nymph commonly, though incorrectly, called the pupa, puparium, or pupal case. The striking metamorphosis of whitefly nymphs into the winged adult suggests a phylogenetic stage intermediate between the hemi- and holometabous insects. Filaments of wax cover the edges of the insect from the third instar through adult life and it excretes increasingly large amounts of honeydew. In heavy infestations this honeydew drips down to cover the surface of the lower leaves and sometimes even the soil. Sooty mold grows on it and photosynthesis and flowering of the plant is reduced. Unlike honeydew from other homopterans, it does not attract ants and wasps (Avidov and Harpaz 1969).

Adults begin to feed on the lower surfaces of the most succulent plant parts soon after they emerge from the last instar. They feed continuously throughout their two-week to two-month life span, flying only when disturbed by strong movement of the leaf. They seem to prefer low-growing plants that shade the entire ground, perhaps due to higher humidity among the dense vegetation (Avidov and Harpaz 1969). Adult B. tabaci were found to be positively photosensitive and negatively geotactic by



El-Helaly et al. (1971b).

### Vectored Diseases

The symptoms of an attack by viruses (or or other undetermined pathogens) known to be vectored by B. tabaci are either a mosaic-type chlorosis of the parenchyma or a curling and stunting of the phloem. The particles most often seen in electron micrographs of infected plants are spherical, but little is known of their composition or taxonomy. The diseases of pulses vectored by B. tabaci are transmitted between host plants neither mechanically, via dodder (Cuscuta spp.), nor through the seed (Costa 1969). There is not yet conclusive evidence that these diseases are specific to the single vector B. tabaci, although it is thought to be a primary vector in many cases. Ahmad and Harwood (1973) in Pakistan obtained no transmission of the easily B. tabaci-vectored yellow mosaic of Phaseolus mungo with three species of aphids, three leafhoppers, and two thrips.

B. tabaci has occurred in Puerto Rico since the 1950's and Bird and Sanchez (1971) divided it into two races on the basis of its ability to live on and vector viruses in certain plants. B. tabaci race sidae vectored the leaf curling-type Rhynchosia virus that affects many legumes, including Cajanus cajan, Canavalia spp., Phaseolus lathyroides, and P. vulgaris.

Bird et al. (1972) described another virus vectored by B. tabaci which they called the golden mosaic virus of Phaseolus lunatus (lima bean). It or a close relative is present in Puerto Rico in crops of P. lunatus, P. lathyroides, and P. vulgaris. Symptoms include yellowing of the veinlets eight days after inoculation by the whiteflies and a mosaic of new leaves as they emerge. These symptoms are similar to others described for a whitefly-vectored mosaic in South and Central America and in Southern Asia (Bird et al. 1972; Costa 1965).

P. vulgaris and P. lunatus are the only two known economically important hosts of golden mosaic in Brazil. Costa (1965) states that commercial plantings often experience 5 to 10 per cent infection, but that special control measures are not usually considered warranted. Dolichos spp. failed to be infected by the mosaic in caged tests and only small differences in tolerance to the disease were noted during screening for resistance of 28 varieties of P. vulgaris.

The yellow mosaic of P. aureus (green gram) and P. mungo (black gram) in India is known to be vectored by B. tabaci (Williams et al. 1968). Infection of these pulses in agriculturally important regions of India is widespread and can be severely damaging to production. Evaluation of several hundred germplasms of these pulses for resistance to the whitefly-inoculated disease resulted in the identification of a highly resistant line of P. mungo, but all samples of P. aureus were susceptible (Nene et al. 1972). Ahmad and Harwood (1973) also reported several highly resistant lines of P. mungo and

note that P. aconitifolius and Glycine max are also susceptible to the yellow mosaic.

Bird et al. (1973) found that the virus can be retained within the whitefly for up to six days and plants exposed to the viruliferous insects became infected after 24 hours of exposure. The percentage of infected plants was proportional to the number of vectors present. The viruses concerned appear to be of the circulative type (Costa 1969). The virus passes from the insect's gut into the haemolymph and reaches the stylet via the salivary glands, unlike the mechanical or stylet-borne type. A single whitefly can produce disease symptoms in a host, although 10 insects per plant were required for consistent transmission (Costa 1965). In contrast to Bird et al. (1973), Avidov and Harpaz (1969) state that the whitefly can remain viruliferous for 10 to 12 days after acquisition. They also noted that the whitefly must lose its ability to transmit before it can re-acquire the virus. The term "periodic acquisition" was suggested.

The development of control methods for insect vectors of virus diseases is difficult, particularly when the host ranges of both virus and vector are so wide. A major difficulty is that even a few survivors of an effective control program could inoculate a field. Fortunately, B. tabaci is sedentary if not disturbed and so does not feed on large numbers of plants. The virus is not subject to transovarial transmission and the immobile nymphs do not play a role in vectoring the diseases (Costa 1969). By avoiding unnecessary disturbances (tractor passes, etc.) it might be possible to reduce the tendency for

the adults to fly, thereby reducing the spread of the disease. This is only speculation, however.

The development of cultivars resistant or tolerant to the vectored viruses is a potentially more practical method of combating B. tabaci than trying to control its numbers. The success of such programs will depend on the presence of resistance in the accessible gene pool and on the ability of the virus to overcome such resistance.

#### Population Regulation

B. tabaci adults are very susceptible to low relative humidity despite the waxy platelets covering their bodies which probably serve to conserve moisture. Hot dry winds occurring in spring and early summer in Israel were found to keep the whiteflies below an economically damaging level throughout the rest of the growing season. This reduction was correlated with humidity below 60 per cent (Avidov and Harpaz 1969). It would be interesting to investigate the possibility that the wind-induced movements of the plants could keep the whiteflies in flight and thereby contribute to lower oviposition rates and higher mortalities. Vakili (1973) noted that excess rains reduce whitefly populations and so recommended planting beans at the end of the wet season.

Manipulation of the microclimate near the soil was found to keep ovipositing adults out of seedbeds. A 1-cm sawdust mulch

lowered the soil temperature but raised that of the air around the plants from 45° to 51° C. Since adults die at 46° to 47° C, oviposition was interrupted (Avidov and Harpaz 1969). B. tabaci is most active during the warmer parts of the day, although oviposition takes place to some extent at all hours (Azab et al. 1971).

Natural enemies of B. tabaci do not appear to have a major effect on population regulation, but knowledge on this topic is sparse. Recorded parasites and predators include Eretmocerus spp. (Hymenoptera: Aphelinidae), Prospatella (= Encarsia) spp. (Hymenoptera: Chalcididae), Ambyseius spp. (Acarina: Phytoseidae), Chrysopa sp. (Neuroptera: Chrysopidae), and unidentified mirids and spiders (Avidov and Harpaz 1969; El-Helaly et al. 1971b; Gameel 1969; Schmutterer 1969). The beginning of B. tabaci's status as a serious pest of cotton in Egypt in the 1950's (Azab et al. 1971) coincided with the widespread use of chlorinated hydrocarbon insecticides. This should be investigated as a possible case of a pesticide-induced population upset.

When environmental conditions allow a build-up of B. tabaci on economically important crops, the traditional control measures have not been very satisfactory. Smit (1964) recommended destruction of the insect's alternate weed hosts. The effectiveness of clean culture to stop winter breeding is questionable due to B. tabaci's wide host range and ability to move considerable distances on the wind. It is probably more useful to concentrate on destroying alternative virus hosts

(Schmutterer 1969) or planting in areas free from large stands of virus-infected weeds (Costa 1965). Vakili (1973) stated that recently-harvested rice fields are usually free of weed hosts of the golden mosaic virus and further warned against planting beans near cotton fields.

Pesticides have not proven to be a simple method of combating B. tabaci. Nicotine sulfate was long recommended but was unsatisfactory for good control. DDT and dieldrin were not much better (Rivnay 1962). The cyclodienes endrin and endosulfan have been used successfully (Avidov and Harpaz 1969) but residues can be a problem in countries where the same fields are used for both green and dry beans. The more potent organophosphates applied as high volume sprays (to drench the nymphs) are now commonly used in preference to the residual chlorinated hydrocarbons (Schmutterer 1969).

The primary problem when controlling whiteflies is penetrating the waxy secretions of the nymphs. Even complete destruction of only the adults is practically useless, for they can be replaced in a few days by unaffected fourth instar nymphs. Systemic insecticides such as dimethoate are useful because B. tabaci is an intercellular phloem feeder and therefore is in direct contact with relatively high concentrations of the poison (Costa 1969). Naresh and Thakur (1972) found that pre-plant applications to the soil of granular systemics such as aldicarb, monocrotophos, and phorate increased yields of P. mungo and reduced B. tabaci and yellow mosaic incidence significantly. The effect lasted only about a month

and subsequent sprays were necessary for maximum yields. The relatively high cost of many systemics and the inherent dangers of using them on food crops should be carefully analyzed, particularly if part of the crop may be harvested green.

Selected References:

Avidov and Harpaz 1969 p.76; Rivnay 1962 p.56;

Schmutterer 1969 p.79; Smit 1964 p.143; Vakili 1973.

Heliothis armigera (Hubner) (Lepidoptera: Noctuidae)

=H. obsoleta F.

=H. rama Bhattacharjee & Gupta [unclear status]

=Helicoverpa armigera (Hubner)

Confused with H. zea (Boddie)

African cotton bollworm, American bollworm, corn earworm,  
gram pod borer, citrus bollworm, tomato worm, cob worm

#### Taxonomy

The Heliothis moths are known for their ill-defined taxonomy. In the field they are probably best separated from other noctuids by their feeding habits and host plants (Smit 1966). Their taxonomy has changed over the years from considering bollworms as a single species throughout the world (usually H. obsoleta or H. zea) to recognizing two dominant species (H. zea in the New World and H. armigera in the Old World) plus several more localized species (Hardwick 1965). This has resulted in much confusion in the literature and accounts for the widespread name "American bollworm" for the Old World species H. armigera.

Hardwick (1965) revised the subfamily Heliothidinae and placed H. armigera and H. zea in the new genus Helicoverpa. Apparently this has not been generally accepted. Bhattacharjee and Gupta (1972) erected the new species H. rama to indicate



what was formerly known in India as the major pest species H. armigera. They do not state if this is a replacement or an addition to the nomenclature for Indian fauna. Since "H. armigera" continues to be commonly used in the literature, it is retained herein.

H. zea and H. armigera are similar in appearance, behavior, and host range, but differ in geography and genitalia. H. armigera is found in Africa; southern Europe; the Mid-East; South, Southeast, and East Asia; Australia; New Zealand; Oceania and Japan (Schmutterer 1969).

#### Damage

The moths of the noctuid family together comprise one of the most damaging of all insect families. The complex of species known as "cutworms" and "armyworms" severely attack all manner of crops throughout the world. The moth larvae of the genus Heliothis have a specialized ability to search out and feed on the fruiting bodies of their diverse range of hosts. This behavior has been explained as being "stimulated by a continuous need for food with a high protein content" (Hardwick 1965). Since these same fruiting bodies are often the most valuable part of the crop to us, it follows that this group is of great concern to farmers throughout the world.

H. armigera is almost omnivorous on plants with fleshy fruits. The Leguminosae and Solanaceae are the most frequent

hosts although flowering maize is often preferentially attacked (Hardwick 1965). Cotton is heavily damaged by H. zea in the Americas. In the Old World, H. armigera seems to be less of a pest of cotton, albeit one of increasing economic importance (Bhattacharjee and Gupta 1972; Pradhan 1969).

The damage to pulse crops by H. armigera can be overwhelming. The production of Cicer arietinum in India is commonly reduced by fifty per cent (Gupta et al. 1971). All pulses are susceptible to some extent, especially when in flower. C. arietinum and Lablab niger are very attractive to ovipositing females even when not in bloom (Hardwick 1965). The most damaging aspect of H. armigera is the tendency for the larva to bore into a developing pod and gnaw on only a few of the seeds, then moving on to many others to do the same. In this manner more seeds are ruined by discoloration and deformity than are actually eaten (Koehler and Rachie 1971). It is very difficult to sort out the damaged seed after harvest, thereby reducing the quality of the crop. High populations of bollworm during time of flowering and pod set are particularly damaging (Passlow 1969). A single larva can eat 30 to 40 Cajanus cajan buds (Koehler and Rachie 1971).

The proclivity of this pest for appearing unexpectedly and irregularly in large numbers often catches farmers off guard. Unless the presence of high populations is detected early, the damage can be done before control measures can be taken (Smit 1966). The ability of H. armigera to fly long distances and rapidly increase its numbers makes it a pest of

even newly developed, isolated irrigation projects in desert areas (Avidov and Harpaz 1969). Methods for detecting impending pest populations of economically significant magnitude have included field surveys of eggs, larvae, or damaged fruit. Egg counts are difficult and unreliable and damage from larvae is not directly proportional to the potential for more harm. Numbers of larvae are therefore considered the most useful indication of a need for control measures (Schmutterer 1969; Shepard et al. 1974).

### Biology

Mating takes place soon after emergence of the adult and the male dies within a few days. The female, however, may spend up to three weeks laying 300 to 3000 eggs on or near potential hosts, particularly if she has a source of nectar. The yellow, truncated sphere-shaped eggs (0.5 mm in diameter) are placed individually, allowing a single moth to infest a very large area (Avidov and Harpaz 1969; Schmutterer 1969; Talhouk 1969). In three to five days the eggs hatch and the larvae begin to feed on tender leaves and shoots. After five to six days they prefer flowers and buds and the later instars feed exclusively on fruiting structures. When devouring the seeds in a pod, the posterior part of their body and a pile of frass are exposed to view (Koehler and Rachie 1971). The larvae are very prone to cannibalism at high population densities, particularly in the

early instars (Twine 1971).

The six larval instars reach maximum size (20 to 40 mm) in 51 days at 17.5°C and 18 days at 22.5°C (Schmutterer 1969; Rivnay 1962). The caterpillars range in color from yellow-green to orange-brown to black. They usually have dorsal and lateral lines of a lighter color and sometimes the spiracles are darkened. Unlike other noctuids, they do not crawl to the soil during the day (Avidov and Harpaz 1969).

Pupation occurs in a chamber formed in the soil about five to ten mm deep. The pupae are identifiable by two spines on the abdomen. Pupation may take as little as 14 days. Toward the end of summer the pupae often go into diapause and do not emerge until favorable temperature and moisture are present the following year. A few days of post-diapause development are required before the adult emerges. Diapause is thought to be temperature dependent, although it has been experimentally induced with a day-length less than 14 hours at 21°C. H. armigera does not go into diapause in equatorial regions (Rivnay 1962).

The total life cycle takes 25 to 40 days in summer and about six months for individuals completing overwinter diapause. Overlapping generations are very common, particularly in regions without marked seasonal change (Avidov and Harpaz 1969).

## Population Regulation

Hot winds reduce female fertility and eggs become nonviable at 38° C. Heavy rains can drown the pupae (Avidov and Harpaz 1969; Rivnay 1962).

Natural enemies of H. armigera probably play an important, but as yet undescribed role in their population regulation. Many chalcidoids, predatory wasps, trichogrammatids, tachinids, and lacewing larvae parasitize or prey upon the larvae. Most programs releasing large numbers of parasites (e.g. Trichogramma spp.) have not successfully reduced the field population of bollworms (Hardwick 1965). The upsurge in pest status of H. armigera in India since World War II as noticed by Bhattacharjee and Gupta (1971) could possibly be the result of a reduction in natural control agents by the use of pesticides. A similar increase in H. armigera is reported for the Sudan after pesticides were widely used against Bemisia tabaci on cotton (Schmutterer 1969).

Viral diseases of Heliothis spp. probably are a major influence on their population fluctuations. A nuclear polyhedral virus selectively effective on five species of Heliothis has been developed to a commercially useful state. It will work best as a supplement to natural controls. It is claimed to be as lethal as most chemical insecticides, although slower acting. The spray requires thorough coverage since the virus particles must be ingested by the larvae to be effective (Ignoffo 1973). Preliminary tests of the commercial formulation

(prepared from H. zea) showed it to be as effective on H. armigera as virus extracted from local African larvae (McKinley 1971). Field trials do not always live up to the expectation of laboratory experiments, however. There are several reports of failure of this method in the field. Older instar larvae are much less susceptible to the virus than younger instars, therefore an application of the virus does not always kill fast enough to be used in the traditional stopgap "insecticide" manner. The breakdown of the virus by ultraviolet light has required special formulation technology (Young and Yearian 1974). Other pathogens are known to be lethal to H. armigera. An infective granulosis virus of Heliothis in southern Africa was found to be transmitted through the feces of the insectivorous cattle egret Arboela ibis throughout its migrations (Gitay and Polson 1971). Bacillus thuringiensis Berliner is lethal to Heliothis spp., although the strains currently used are not capable of creating epizootics. It is available in commercial formulations.

Attempts to control H. armigera's damage by reducing its regional population have generally been unproductive (Hardwick 1965). The ability of the moths to fly long distances have counteracted such practices as crop rotation, fall ploughing, and flooding to kill pupae. Killing adults with ultraviolet light traps or poisoned baits is not practical due to their large numbers. Presently available repellents are incapable of protecting field crops such as pulses because they generally have a small region of influence and a short life span.

The most successful control programs for Heliiothis have been those aimed at reducing the population of insects that are on the crop and actually damaging it, rather than trying to reduce the general population over a wide area. This approach has included early planting to avoid having the crop in an attractive stage (i.e. flowering) when the first major flight occurs in the spring. The use of trap crops to lure ovipositing females from the more valuable crop has given varying results. The females seem to prefer laying eggs on the lower of two equally attractive plants (Hardwick 1965) and in Africa Lablab niger is used as a trap crop to protect cotton. Maize is also grown near beans to protect the latter. Conflicting and inconsistent reports, however, limit the usefulness of this method (de Pury 1968; Schmutterer 1969).

Chemical pesticides have proven themselves effective against bollworms when used correctly. Cryolite, arsenicals, fluorosilicates, and botanical insecticides were moderately successful in the early days, but the introduction of DDT overshadowed them all (Hardwick 1965). Commonly employed persistent synthetic pesticides include mixtures of DDT and endrin, BHC, toxaphene, and endosulfan. Organophosphates such as parathion and trichlorphon are frequently recommended now that the environmental hazards of the more persistent chlorinated hydrocarbons are acknowledged. Carbamates such as carbaryl are generally only moderately effective, and are phytotoxic in working dosages to some pulses (Gupta et al. 1971; Frohlich and Rodewald 1970; Smit 1966; Koehler and Rachine 1971;

Rivnay 1962).

Resistance of H. armigera to DDT is reported only from Australia and Thailand (Wilson 1974). H. zea and particularly H. virescens (F.) in the Americas are resistant to both chlorinated hydrocarbons and organophosphates. It took only ten years for resistance to develop in Australia, whereas it took 20 years in the United States.

Selected References:

- Avidov and Harpaz 1969 p.340; Hardwick 1965;  
Rivnay 1962 p.119,387; Schmutterer 1969 p.178;  
Smit 1966 p.219; Talhouk 1969 p.192.



Ophiomyia phaseoli (Tryon) (Diptera: Agromyzidae)

=Melanagromyza phaseoli (Tryon)

=M. phaseoli (Coq.) [common but invalid authority]

=Agromyza phaseoli Coq.

bean fly, snap or French bean fly, bean stem maggot,  
(pigeon) pea stem borer, agromyzid fly

#### Taxonomy

The recent monograph by Spencer (1973) on agromyzids of economic importance clarifies many of the misunderstandings regarding the taxonomy of Ophiomyia phaseoli and its close relatives. Spencer moved the bean fly from the genus Melanagromyza to Ophiomyia as the result of detailed studies on the adult genitalia, larval anatomy, and feeding habits. Most references to this species in all but very recent literature are to Melanagromyza phaseoli.

The adult bean fly is externally nearly identical to several other agromyzids that attack pulses. Recently, Greathead (1969) determined that the bean fly population in parts of Africa is actually a mixture of two species, O. phaseoli and O. spencerella (Greathead). The latter is probably of even greater economic importance in Africa because it preferentially attacks the youngest plants.

Identification of damaging agromyzids has been greatly facilitated by the key to genera and descriptions of species and their damage compiled by Spencer (1973).

## Damage

The bean fly is a key pest of most species of pulses in tropical and sub-tropical Africa, the Mid-East, South and South-East Asia, Australia, and Oceania (Commonwealth Institute of Entomology 1961). O. phaseoli is a pest of the Old World, but it presents a constant challenge to quarantine organizations in the Americas due to its potential for destruction there. It was accidentally introduced into Hawaii in 1968 and quickly spread throughout the islands (Davis 1970).

The host plants of O. phaseoli include all of the economically important species of Phaseolus. Considerable damage is also done to Glycine max, Vigna unguiculata, and Cajanus cajan and it can survive on many wild legumes. Reports indicate that several legumes are relatively immune to O. phaseoli, including Phaseolus sublobatus Roxb., Lupinus spp., Cicer arietinum, Pisum sativum (Spencer 1973), Vicia faba (Abul-Nasr and Assem 1966), Canavalia ensiformis and C. gladiata (Davis 1969)! Crotalaria sp. is reported as a host by de Pury (1968) but larvae did not complete their development on it under experimental conditions (Greathead 1969). Some species and varieties appear more susceptible to attack than others, Phaseolus vulgaris usually being the most devastated (Walker 1960).

Closely related stem borers specialize on other pulses, such as Melanagromyza vignalis Spencer on Vigna unguiculata and M. sojae (Zehnt.) on Glycine max. Several of these agromyzids have adapted to burrowing in the pod of pulses rather than the

stem. Examples include M. obtusa (Malloch) on Cajanus cajan and M. bonavistae on Lablab niger and Vigna unguiculata (Greathead 1971).

The severity of the damage inflicted by Ophiomyia phaseoli is due to the destruction of the stem tissue of young seedlings. An entire crop can be virtually destroyed in the first two weeks after emergence if high populations of the fly are present. The disruption of the vascular system by the older larvae and puparia is responsible for most seedling mortality. White streaks, swelling, lesions, and cracks down the stem are indications of the maggots' presence (Avidov and Harpaz 1969). It takes only one or two larvae to kill an emerging seedling. Vigorously growing plants can sometimes survive with up to four larvae per stem, but commonly 20 or more are present (Ho 1967). Walker (1960) noted that the cracks allow termites to gain entrance and Talhouk (1969) considered that the infection of the lesions with saprophytic microorganisms is an important contribution to the damage. Plants over three weeks old can usually sustain high levels of infestation without appreciable losses in yields (Ho 1967), although such infested branches are prone to breakage (Walker 1960). Control of the bean fly is therefore most important while the plants are young.

Some bean plants are able to develop adventitious roots above the area of stem mining and can thereby circumvent the interference with the vascular system, although reduced growth potential is inevitable. Several authors have remarked on the ability of seedlings to survive a light to moderate attack.

if it is followed by wet weather. Presumably this allows the adventitious roots to get established before the plant is desiccated (de Pury 1968; Ho 1967; Greathead 1969). The practice of farmers in many countries of hilling soil around the stems takes advantage of the production of adventitious roots. (Davis 1969). It was noted that cultivars introduced into Africa from temperate regions did not have the tendency to form adventitious roots compared to the local beans that had long been the target of natural selection (Greathead 1969). Losses from the bean fly are particularly severe during periods of drought (Frohlich and Rodewald 1970).

The extent of damage to pulse crops in a susceptible region often fluctuates with the season, year, and specific location. It has not been practical to evaluate the need for chemical control measures on a field-survey basis since the damage is done within such a short time after emergence. A pesticide must be in place while the plants are young and susceptible, otherwise it may be too late. The factor of timing becomes crucial when dealing with large or inadequately attended fields. As a result, the crop is usually treated on an "insurance" or "calendar" basis, whether or not the insect has reached an economic level. There is a need for developing methods for more accurate predictions of populations in areas where O. phaseoli is not a constant problem.

The damage caused by O. phaseoli is sometimes confused with that of Alcidodes leucogrammus (Erichs.), the striped bean weevil. The maggots are easy to mistake in the field for those

of various saprophagous diptera (Greathead 1969).

### Biology

The fertilized females of O. phaseoli are most active on warm, clear days. They tend to lay their eggs during the morning on the upper sides of cotyledons and leaves, often near the petiole. On dull, rainy days they oviposit more on the undersides (Davis 1969; Rivnay 1962; Wyniger 1962).

The female uses her ovipositor to repeatedly puncture a leaf's epidermis with a slanted slit whose opening is toward the main stem (Greathead 1969). She "excavates" a small space within the parenchyma or vein tissue and lays a single, oval, nearly invisible, 0.775 x 0.35 mm, white egg (Ho 1967; Spencer 1973). The eggs were found in only one-tenth of the punctures by Davis (1969). The female is known to imbibe the sap that exudes from the punctures. The act of oviposition creates a small, yellow, translucent, sunken "window" in the leaf's epidermis (Ho 1967). A few eggs may be laid in the stems near the ground rather than on the leaves or cotyledons (de Pury 1968).

After about two days the eggs hatch and the yellow-brown larvae mine through the parenchyma. In leaves they initially mine towards the distal end of the leaf. Upon meeting a leaf vein they turn and follow it to the midrib and continue down the petiole. The leaf mines are most visible from the underside (Ho

1967). In young plants the larvae mine the inner epidermis of the main stem to about ground level. Unlike members of the genus Melanagromyza, Ophiomyia spp. do not feed in the inner cortex of the stem unless they are overcrowded (Spencer 1973). On older plants they complete their larval instars and pupate below a stem node before reaching the lower main stem, therefore not usually causing lethal damage (Avidov and Harpaz 1969; Greathead 1969).

The larval period lasts eight to ten days under warm summer conditions and up to 40 days during winter (Davis 1969). The larvae of O. phaseoli have conspicuous, uneven mouth hooks and yellow, conical projections on their posterior spiracles. The third instar larvae just before pupation are 2.5 to 4.25 mm long (Ho 1969; Spencer 1969). The light to dark brown puparium (up to 3 mm long) is found within the stem under a thin layer of epidermis.

The adult flies emerge from the puparia after 7 to 20 days, depending on the temperature (Ho 1967; Spencer 1973). The female passes through a two day pre-oviposition period before a two-week period of laying eggs (Spencer 1973). Rivnay (1962) reports an average of 94 eggs and a maximum of 183 per female. The imago is a shiny, black, "typical" agromyzid with "wine red" eyes. It is from 1.5 to 2.0 mm long, the female distinguished by a blunt posterior abdomen (Talhok 1969). The life cycle of O. phaseoli ranges from 12 to 48 days, approximately three to four weeks being common in the summer (Avidov and Harpaz 1969; Talhok 1969; Spencer 1973).

## Population Regulation

O. phaseoli reaches the high populations that make it an economic pest only during months of moderately warm weather. The population tends to fluctuate annually in all but the most consistently warm climates. Late summer through autumn is usually considered the period of serious damage in Australia (Davis 1969) and the Mid-East (Avidov and Harpaz 1969; Talhouk 1969). In India, however, Pradhan (1969) described O. phaseoli as a pest of "temperate" weather, one that is abundant during the spring, fall, and sometimes winter but not thriving in the intense heat of summer. The sowing date of the late summer crop was not found to affect the level of infestation in Egypt (Abul-Nasr and Assem 1968). The spring crop, exclusively used for green pods, was attacked only lightly. There is some confusion here as to what people from different climates considered typical weather for each season.

Cultural controls of regional populations of O. phaseoli have generally not proven practical. Pulses grown in East Africa are exposed to particularly high populations of bean flies if successive plantings are made throughout the long growing season that is made possible by irrigation (de Pury 1968). The relatively cheap protection available with insecticides does make interruptions in potential plantings an unacceptable alternative to farmers.

Other cultural controls recommended in Kenya included the burning of infested plants and "earthing up" soil around the

lower stems to trap emerging adults (Wallace 1939). Placing rice straw mulch over the emerging seedlings was thought to reduce the level of oviposition. This would be an interesting method to test more rigorously. The removal of infested leaves is recommended for light infestations (Pradhan 1969) but would be practical for gardens at best. The presence of a wide variety of wild legume hosts of O. phaseoli makes pointless most attempts at reducing populations by denying cultivated hosts. In a few situations irrigated cropland does make crop rotation a possible cultural control during the dry season, since most wild hosts will have dried up.

Overcoming damage by the use of cultivars selected for resistance to O. phaseoli has not received adequate attention. Preliminary field trials were carried out in the Phillipines to evaluate resistance of Phaseolus aureus to this pest's damage (Balboa 1972). Two of the five named cultivars tested showed superior survival rate and overall yield. Contributing factors may include a thick, pubescent, tough stem although general vigor probably played an important role in overcoming the maggot's attack.

The natural enemies of O. phaseoli are known to significantly reduce populations, but usually not enough below economically tolerable levels to be easily noticed. Studies undertaken by the Commonwealth Institute of Biological Control's East Africa Station (Kampala, Uganda) have indicated the importance of several parasites. The most effective of these is Opius melanagromyza Fisch, a braconid with a density-dependent



relationship to its host. Although parasitism is usually over 50 per cent, damage to pulses is still severe (Greathead 1969).

O. melanagromyza was sent to Hawaii to combat the newly arrived Ophiomyia phaseoli. Up to 80 per cent parasitism was reported (Davis 1970).

Many other parasites have been identified in the bean fly, including chalcids, pteromalids, eurytomids, eulophids, cynipids, and eupelmids. Spencer (1973) provides a compilation of parasite records from Java, Australia, East Africa, and Egypt. Additional records from Egypt are given by Abul-Nasr and Assem (1968).

The use of broad spectrum insecticides undoubtedly reduces the populations of natural enemies and in the long run increases the damage potential of this pest (Spencer 1973). Experiments on other agromyzid pests on vegetables have indicated the value of selective insecticides, such as dimethoate and dioxathion, that are lethal to the leaf-miner but not its enemies (Getzin 1960). Unfortunately, no conclusive data is available for insecticides with such selectivity to O. phaseoli.

The first effective means of protecting young beans was sprays or dusts of nicotine or rotenone. Sprays of oil, kerosene, and carbolic acid were used with less success (Ho 1967). Chlorinated hydrocarbon insecticides were found to be quite satisfactory for control of O. phaseoli and DDT is still applied to young plants in several successive sprays in many parts of the world (Davis 1969). Field experiments in Malaya tested sprays of five chlorinated hydrocarbons and eight

organophosphates. Dieldrin was the only one of the former that did not provide good control. The organophosphates malathion and trichlorphon did not perform satisfactorily, despite their common use by farmers. Diazinon was considered the best from the dual standpoint of cost and effectiveness (Ho 1967).

The treatment of seeds and soil before planting has been popular because it protects the seedling in its most critical stage. Endrin has been most commonly used. However, care must be taken in treating the seed or the germination and vigour of the plants will be reduced (Jones 1965). Seed treatment was suggested as a practical means of protecting less valuable crops, such as Vigna unguiculata, that are not usually sprayed (Davis 1969). Endrin applied as a soil soak is transported systemically into the leaves of young beans and can kill the larvae there. No repellent action towards ovipositing females was found during studies by Wickramasinghe and Fernando (1962). Dusts of aldrin and BHC applied to the soil before planting reduced the infestation rate in Cajanus cajan from about 50 to 25 per cent (Singh 1970). Pre-plant granular applications of the newer insecticides phorate, monocrotophos, and aldicarb provided good bean fly control on Phaseolus mungo for up to four weeks (Naresh and Thakur 1972).

## Selected References:

- Avidov and Harpaz 1969 p.431; Davis 1969;  
Frohlich and Rodewald 1970 p.223, plate 34;  
Greathead 1969; Ho 1967; Rivnay 1962 p.239;  
Spencer 1973 p.4,12,21,61,342; Talhouk 1969 p.219.

### III. THE ROLE OF PEST MANAGEMENT IN INCREASING PULSE CROP PRODUCTION

#### 1. FACTORS INFLUENCING THE PRACTICE OF PEST MANAGEMENT ON PULSE CROPS

Control of insect pests can provide significant production dividends for pulse crops grown at nearly any level of agricultural technology. In reference to soybeans grown in the United States, Turnipseed (1972) stated "Probably no other insect complex of a major crop affords better opportunity for immediate and long-term success with a modest research effort". This is also true to a large degree in countries where even the actual pest species have not been firmly characterized. The loss in yield of pulse crops as the result of insect damage was estimated by Bindra (1968) as between 10 and 15 per cent for all of India. Booker (1965) reported a tenfold increase in cowpea yield as the result of pesticide sprays, compared to the national average in Nigeria. While such tests are not necessarily representative of the level of control possible for the actual farmer, they do indicate the potential level of loss attributable to insects. Plant diseases and weeds are probably even more damaging to pulses as a whole than the insects, and so represent another aspect of pest control needing continuing research. The general question of improving pulse production in developing countries has been discussed by Masefield (1967),

Reem (1967), and Stanton (1970).

Entomologists, like the practitioners of most scientific disciplines, attend to problems in a selective manner that reflects the value of the work to their society. In most cases economic values are foremost. The worth of the discipline to society is generally considered to be relative to its ability to negate factors such as pest losses that inhibit production and profits. Development of agricultural entomology in the industrialized countries therefore was, and continues to be, stimulated by a ready cash market for food and fibre. Under such conditions pulse pests have received an amount of study generally in line with their economic value. Those cultivars of pulse species that produce pods or seeds eaten or processed while still green have probably received more attention from entomologists, plant pathologists, and plant breeders than those grown for dry seed. This is largely because of the higher price that vegetable-type legumes command per hectare than pulses, economic damage from pests therefore being a greater liability.

When scientific pest control was introduced to the Third World by colonial governments or by corporations, efforts were concentrated on those crops that produced cash revenues. In most cases these cash crops were not food crops or, at least, did not include local subsistence staples such as pulses. As a result, plant protection scientists working in the Third World have historically put little emphasis on the local pulse crops, perhaps with the exception of groundnuts grown for oil.

If pulses in developing countries are to justify the cost of improved pest control, they must have a market that can absorb increased yields while maintaining good prices. This is a prime problem in many countries. Farmers will not finance improved production techniques if prices fall from a resulting "surplus". The possibility of pricing pulses out of the reach of the people who need them most is particularly apparent in areas where they are mainly a subsistence crop.

Leakey (1973) proposed that beans grown for seed in regions of low rainfall in the tropics could become a crop justifying relatively high levels of production technology such as pest control. This would follow the experience of North America where seed production is limited to the arid West. Crops grown on the slopes of Mt. Kilimanjaro and perhaps the Andes would avoid many seed-borne disease problems encountered when seed is produced in the humid tropics. Progressive lowland farmers would be likely to pay premium prices for seed that is convincingly disease-free.

Chemical control of pests in developing countries is increasingly being hampered by the rising expense of all petroleum products. In addition, the high acute toxicity of many of the newer compounds require rigorous safety precautions. Intercropping, a phenomenon primarily of the tropics, presents highly complex problems in terms of toxicity to both the plants and beneficial insects. Davies (1974a, 1974b) suggested that under such circumstances the use of insecticides will remain

less intense than in developed countries for some time to come. Insecticides were seen as being of greatest value when used in special applications such as seed dressings or to protect research plots.

The scarcity of qualified workers in agricultural research and extension in Third World countries and the often transient nature of scientists visiting from industrialized countries has resulted in a dearth of cohesive, basic scientific data on the ecology of tropical agricultural systems. The numerous decades that it took scientists in temperate regions to reach their present state of knowledge concerning agriculture should make one realize the difficulties encountered when trying to obtain valid results from work in developing regions under far more pressing time constraints. These regions are likely to produce the most dramatic increases in production yet to come, but one should not be misled by naive ideas such as the inherently great potential for productivity of tropical agriculture. In much the same way that some temperate cultivars are often not adapted to tropical conditions, so too must agricultural science, including entomology, be willing to approach these unfamiliar regions without undue assumptions based on experiences gained under temperate conditions.

## 2. MAJOR PEST MANAGEMENT RESEARCH EFFORTS FOR PULSE CROPS

The development of the pest management concept in industrialized nations is the result of experience gleaned from decades of experimental research and observation. In North

America, pest management has come to mean a high level of understanding of a crop's culture, economics, and the available control methods. It is being popularized as a means of reducing losses through the integration of various control methods that are implemented on the basis of periodic pest population surveys. In addition, it is hoped to be a method of reducing the environmental damage that can come from over-use of certain pesticides. There is the possibility in the foreseeable future of the use of complex mathematical models utilizing inputs of both biotic and abiotic factors that would allow control measures to be based on the probability of a pest's potential for damage. Ecological models have been developed for many crop-pest systems, but the level of accuracy needed to apply them to practical problems has usually been lacking. Soybeans in the southern United States have recently become the subject of a coordinated effort at modeling (Newson 1974).

Pest management programs in over 30 states are being funded by the U.S. Department of Agriculture. The basic plan calls for "scouts" to check selected fields at weekly intervals, the decision to apply pesticides being made on the basis of their counts of pest populations. Cultural practices are also noted in the hope of integrating them into the program. Soybean has been a major target and local programs have recently included peanuts (French 1973; Hoelscher et al. 1973) and lima beans (Bushing and Burton 1974; Dively and Caron 1974). These pilot programs are likely to become the standard for control of insects, plant diseases, and weeds on crops whose value justifies the added



expense. In some cases they may be carried out by "pest management specialists" who are hired by the farmer to take charge of pest control responsibilities (Council on Environmental Quality 1972).

If pest management necessarily involves the sophisticated level of applied science now being experimentally attempted on a few pulse species in the USA, what is its potential for those parts of the world that are still struggling to feed themselves? If pest management is meant to refer only to supervised, integrated control programs carefully designed for a specific crop in a specific locality, then it is a long, long way off for pulse crops grown in developing countries. However, the term has suffered in exactness of meaning by its multitude of definitions and has come to be used by many to indicate an attitude toward the problem rather than as a particular control strategy. This viewpoint sees pest management as a process utilizing the best available, yet economically practical control methods, keeping in mind the potential environmental drawbacks that can accompany some control programs. This less strict definition tries to acknowledge a control program's relative advance over previously employed methods, but it effectively dilutes the meaning of "pest management" from the original.

Relatively great improvements in pest control can take place during the early stages of a country's development of agricultural technology if adequate numbers of trained personnel are available. Often cultural controls requiring a greater change in the farmers' habits than in their technical expertise

can be implimented by extension workers having only moderate training. The training of agriculturalists specializing in edible legumes specifically for and in developing countries was discussed by Fernandez (1973).

In the last decade or so the overriding importance of drastically increasing the world's agricultural productivity has generally become acknowledged. Pulses will necessarily be a vital part of this effort, for reasons presented in the introduction. On a global scale probably a majority of humanity depends on the "poor mans meat". The affluent nations may consider pulses of secondary importance, but the trend toward food shortages on all fronts will likely drive up the value of pulses throughout the world.

The realization that coming food scarcities could have widespread and unsettling effects on the international political and economic situation, in addition to causing widespread suffering, prompted action from holders of key positions in many Western nations. One result that revolutionized agricultural research for the Third World was the establishment of international research institutes endowed with funds derived from both private foundations and governmental agencies. Lines of genetically improved wheat, corn, and rice developed at the International Center for Maize and Wheat Improvement (CIMMYT) and the International Rice Research Institute (IRRI) became the foremost articles of the "green revolution". Great increases in yields in many countries have in fact been realized, but they must be accompanied with the understanding that such advances

are only buying time unless population growth is restrained. The effectiveness of international institutes working on specific crops became apparent and several more are now in operation. Those whose work includes pulse crops are described below.

The World Bank in 1971 agreed to take over the financing of most of these institutes from their former sponsoring foundations, primarily Ford and Rockefeller. A Consultative Group on International Agricultural Research (CGIAR) was formed under the joint sponsorship of the World Bank, the Food and Agriculture Organization (FAO) and the United Nations Development Programme (UNDP) with Canada playing a leading role. The CGIAR consisted of 29 countries as of 1973 and funded six institutes. A Technical Advisory Committee of twelve scientists was also established to suggest research priorities (World Bank 1971, 1973).

Each of the institutes employs an international selection of scientists who are assigned the important tasks relative to increased food production. The great need for cooperation between the institutes and research workers at more local institutions was stressed by Nickel (1974). The new seeds and improved husbandry techniques developed at the institutes must be tested and evaluated by local workers since their feedback determines the rating of an item's actual success in the field. Building and utilizing large germ plasm collections for plant breeding is the mainstay of all the centers, but crop protection systems are also being developed for the improved cultivars.

At least three of the institutes funded by the Consultative Group are now undertaking research responsibilities for specific pulse crops. A Grain Legume Improvement Program was begun in 1970 at the International Institute of Tropical Agriculture (IITA) [P.M.B. 5320, Ibadan, Nigeria]. This institute has been assigned by the ICGAR primary world responsibility for cowpea research and secondary responsibility for soybean and pigeon pea. Some work is also being carried out on mung and lima beans. The latter has proven itself to possess an "unusually high level of reliability and productivity" in the humid tropics (International Institute of Tropical Agriculture 1973). About 90 per cent of the entomological program is devoted to pests of cowpeas. Cultivars have been discovered which possess a tolerance to leafhoppers and thrips and which interact synergistically with applications of selective insecticides. This may provide the beginnings of an integrated control program.

The International Center for Tropical Agriculture (CIAT) [Apartado Aereo 67-13, Cali, Columbia] specializes in research on cassava and common beans. The entomology program includes developing safe controls for the bean bruchid, Zabrotes subfasciatus (Boh.), a severely damaging pest of stored products. An integrated control package for leafhoppers and spidermites is also being actively pursued (A. van Schoonhoven, personal communication). The proceedings of a seminar held at CIAT in 1973 on "Potentials of field beans and other food legumes in Latin America" have been published and provide one of the most

up-to-date and extensive discussions of pulse crop research for developing countries available (Wall 1973).

The recently established International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) [1-11-256, Begumpet, Hyderabad 500016, A.P., India] has primary responsibility for chickpeas, pigeon peas, and groundnuts. The program is just getting underway in 1974 and will include an entomology section (C. F. Bentley, personal communication). ICRISAT is currently compiling a directory of research workers on pulse crops (P. J. Shannon, personal communication).

The Asian Vegetable Research and Development Center (AVRDC) [P.O. Box 42, Shanhua, Tainan, Taiwan] is another recent addition to the pool of expertise. It is beginning a breeding program to include seven species of Phaseolus, cowpea, and goa bean (Psophocarpus tetragonolobus) (MacKenzie 1973). No information was available on the beginning of entomological work there.

Soybeans have reached very high levels of productivity in the midwestern and southern United States. The International Soybean Program (1974) (INTSOY) of the University of Illinois and the University of Puerto Rico is concerned with all phases of soybean production, protection, and processing. One of its earlier projects surveyed potential soybean producing areas in India and identified several regions suitable for this crop where it had not been commonly grown (Reem 1967). Recently INTSOY expanded its activities to provide information resources, research coordination, special training, and technical assistance

for developing countries. The directorate is at the University of Illinois [113 Mumford Hall, Urbana, Illinois].

The International Development Research Centre of Canada has provided funding for nine overseas projects dealing with improving pulse production between its establishment in 1970 and June 1974. Major projects have included: a leading role in the establishment of ICRISAT in India; funding of pigeon pea research at the University of the West Indies, Kingston, Jamaica; and aid to the Arid Lands Agricultural Development Program (ALAD) in Beirut, Lebanon (International Development and Research Centre 1974; Veinotte 1974).

The United States Department of Agriculture (USDA) and the U.S. Agency for International Development (USAID) have been officially involved in many grain legume improvement projects in the Third World. The USDA has sponsored dozens of research efforts on pulse crops and their pests at foreign institutions under the "Special Foreign Currency Program" (Public Law 480). Under this program, funds accruing to the USA for goods provided are spent in the country of origin. Indexes to the projects and their results are available (U.S. Department of Agriculture 1974a, 1974b).

The Regional Pulse Improvement Project (RPIP) was initiated by USAID in Iran in 1965 and the following year in India. Small teams of U.S. Agricultural Research Service scientists were stationed in each country and formal working relationships were established with the local agricultural

research centers. Results were not of the dramatic "miracle grain" variety that had been expected by some without justification. Improvement of tropical pulses was a different situation compared to crops such as wheat that were already highly developed in temperate regions. There was no simple transfer of technology or cultivars possible and the work was too basic to expect great returns in only a few years. A bibliography on 31 species of pulse crops was prepared referring to approximately 20000 articles, 6000 of them abstracted (Regional Pulse Improvement Project 1969, 1970). Unfortunately, it has not been published (J. M. Schalk, personal communication). The USA pulled out of the RPIP in India in 1970 and from Iran in 1971 due to budget cuts.

The RPIP stimulated a large increase in pulse interest and research capability and national organizations are continuing the work. The Plan Organization of the government of Iran is funding research on several pulses, particularly chickpea, lentil, and mung bean. An important result of the work there has been the identification of cultivars whose seeds are not attractive to oviposition by Callosobruchus spp., serious pests of pulses in both field and storage (Schalk 1973). The Indian Congress on Agricultural Research established the All India Coordinated Pulse Project to carry on the work begun with the RPIP. India is a producer and consumer of vast amounts of pulses and its agricultural universities and institutes are conducting a very significant amount of the world's research on tropical pulses.

The Brazilian National Soybean Program was initiated and participated in by USAID, the IRI Research Institute [of New York], and several universities in the USA. Yield trials and the importation of soybean cultivars from the southern United States were the major accomplishments (Reem 1967). Brazil, the world's largest producer of Phaseolus vulgaris, has carried out research on beans since the early 1960's under the coordination of its National Bean Commission. A National Bean Project is now underway at the Federal University of Vicosa, [Vicosa, M.G., Brazil] (Robitaille 1974). Primary work will be on nitrogen fixation and germplasm screening for disease resistance and favorable cultural characteristics.

Pulse research in Latin America is spread widely throughout many universities and organizations. Pinchinat (1973) reported the results of a survey on pulse research conducted by the Instituto Interamericano de Ciencias Agricolas (IICA) [Turrialba, Costa Rica] of the Organization of American States. The IICA's Centro Interamericano de Documentacion e Informacion Agricola (1972) (CIDIA) is a prime source of information on pulses and has produced several editions of comprehensive bibliographies on Phaseolus spp. and Vigna spp.

Efforts are underway to develop an information network among food legume workers in Latin America to help coordinate efforts and publicize results. Proposals (Anon. 1973; Monge 1973) have called for the establishment of an organizational publication similar to that provided by the Bean Improvement Cooperative (1974) (BIC), an organization primarily oriented



to North America.

At many research institutions, entomological research on pulses is meshed with not only other aspects of plant protection, but with the whole problem of legume production. The need for such inter-disciplinary approaches is particularly evident at the international crop improvement centers where plant breeding is a prime component of the program. If new cultivars are to be commercially successful, they must be developed through a holistic approach that includes resistance to diseases and insects, high productivity at moderate rates of cultural and energy input, and good marketing qualities.

These examples of research efforts on pulses are not comprehensive. Almost every moderately advanced country is making some effort in the control of insects on pulses, usually as part of a vegetable or field crops program. However, the programs outlined above do include most of the large-scale or international efforts specifically concerned with pulses, particularly those in the Third World. This indicates the recent advent of intensive research on pulses grown in developing countries and the problems yet to be overcome if pulses are to make their potential contribution to the human diet. Pulses have belatedly but widely become a popular subject for research. The possibilities inherent in the largely untapped gene pool and the common lack of sophistication in pest control provide a fertile field for needed research, if only economics and politics will allow.

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