

# The Beanfly Pest Complex of Tropical Soybean

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## Introduction

Of all the insect pests that infest soybean (Glycine max) in the tropics and subtropics, Agromyzids - beanflies - are the most destructive. Eight species have been reported: Ophiomyia phaseoli, O. centrosematis, O. shibatsuji, Melana-gromyza sojae, M. dolichostigma, M. koizumii, M. vignalis, and Japanagromyza tristella.

O. phaseoli, O. centrosematis, M. sojae, and M. dolichostigma are the most destructive species in tropical Asia. The first three feed mainly in the stems of young seedlings, whereas M. dolichostigma feeds in the young shoots (four weeks or older). In Indonesia, Thailand, and Vietnam beanfly infestation, especially O. phaseoli, can result in losses of up to 100%.

Beanflies are found in most tropical areas, but damage is generally higher in latitudes closer to the equator. The insects feed on a wide variety of cultivated and wild legume crops.

## Taxonomy and Identification

The identification and nomenclature of agromyzid flies was unclear until the publication of Spencer's (1973) monograph.

All adult beanfly species have a similar appearance. The key identification criteria are the location of larval feeding sites in the host plants and the shape and size of the insects' anterior and posterior larval and pupal spiracles.

### *O. phaseoli*

The larva has small anterior spiracles that consist of a circle of six minute bulbs. Posterior spiracles are closely adjoined and rise on a conical projection with about 10 bulbs (Fig. 1). The puparium is pale yellow (straw colored) or brown, and 3 mm in length. The major feeding and pupation site is the main stem between the outer epidermis and the cortex.

### *O. centrosematis*

The larva has anterior spiracles on long black stalks and posterior spiracles on short stalks, each with three bulbs (Fig. 1). The puparium is yellow or red-orange. Major feeding and pupation sites are located on the main stem between the outer epidermis and the cortex.

### *M. sojae*

The larva has short, knob-like anterior spiracles with eight minute pores. Posterior spiracles are distinctly separate, and they normally consist of six raised pores around a central truncated horn (Fig. 1). The puparium has a

yellow-brown color. The insect's major feeding and pupation sites are located in the pith of the main stem.

*M. dolichostigma*

Larval anterior spiracles are unusually long, and have 12 minute pores. Posterior spiracles are shorter, and contain about 15 pores (Fig. 1). The puparium is oval, yellow-brown in color, and 2.5 mm long. The major feeding and pupation sites are the young shoots of 4-week-old plants.

	<i>Ophiomyia phaseoli</i>	<i>Ophiomyia centrosemat</i>	<i>Melanagromyza sojae</i>	<i>Melanagromyza dolichostigma</i>
<u>Larva</u>				
Last instar				
Anterior spiracles				
Posterior spiracles				
<u>Pupa</u>				
Anterior spiracles				
Posterior spiracles				

Fig. 1. Morphological characteristics of four beanfly species.

## Biology

*O. phaseoli*

Oviposition takes place in young leaves, both on the upper and lower surfaces (Greathead 1968, Ali 1957). In Indonesia, the insect also lays eggs in soybean cotyledons (van der Goot 1930) (Fig. 2). A single female can lay up to 300 eggs in a 2-week period (Otanés 1918, Raros 1975). The eggs hatch in two to four days. The larvae form a short leaf mine, but then enter the nearest vein and proceed into the petiole and down into the stem. Larval tunnels in the cotyledons are initially directed towards the apex, and later follow an irregular course before reaching the leaf base (van der Goot 1930). In young plants, most feeding takes place in the lower cortical layers of the stem, but some larvae penetrate into the tap root. With heavy infestations, the larvae feed deep inside the stem, as well as higher up on the plant. The larval stage lasts for ten days, and the pupal stage lasts an additional nine or ten days. Both periods

are shorter under higher temperatures or longer under lower temperatures. In Zimbabwe the complete life cycle can take as little as three weeks when temperatures are high (Taylor 1958). In the Indonesian highlands, the larval stage can last from 17 to 22 days, and the pupal period can take as long as 13 to 20 days (van der Goot 1930). Hassan (1947) reported that the life cycle in Egypt can be completed in 17 days. The puparium remains beneath the epidermis, normally near the base of the stem (Greathead 1968).

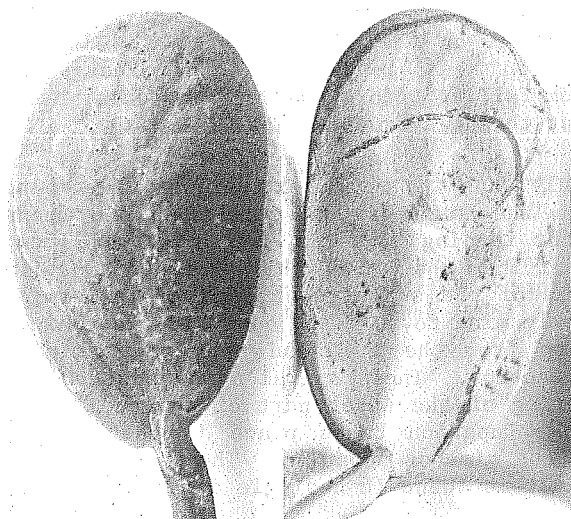


Fig. 2. *Ophiomyia phaeseoli* feeding/oviposition punctures and feeding mines on the upper (left) and lower (right) surfaces of soybean cotyledons in Indonesia.

### *O. centrosematis*

Greathead (1968), working in East Africa, showed that oviposition takes place not in the leaves, but in the hypocotyl and stem. Similar oviposition habit was found at AVRDC, but elsewhere in Taiwan Lee (1976) found that the eggs are laid in soybean leaf tissue. The larvae feed just beneath the epidermis of the stem and in part of the tap root. No larvae were found feeding within the pith of the main stem or roots (Lee 1976). The larva pupates just beneath the epidermis. In most cases, the anterior spiracles of the pupae pierce the dry epidermis and project outward. In the laboratory, development time from egg to adult was 30 days at a mean temperature of 21°C (Greathead 1968).

### *M. sojae*

Oviposition takes place exclusively in the leaves. The first trifoliolate leaves are preferred (van der Goot 1930), and the eggs are always laid on the underside of the leaf in the mesophyll tissue. Numerous feeding punctures, however, are made on the upper side of the leaves. The eggs are most frequently laid near the base of the leaf, but can be found elsewhere in the leaf blade (always near the leaf vein) (Spencer 1973). Wang (1979) reported that the female lays an average of 171 eggs (range of 41 to 275 eggs/lifetime).

The larva hatches after two or three days, immediately bores into the nearest vein, and continues feeding through the petiole into the stem. It then feeds internally in the pith, bores down to the root, and then again feeds upwards until it is fully grown. It pupates in the stem, but first mines a hole to the epidermis to assist in the emergence of the adult. Normally only one larva completes its development in a younger plant, although two puparia have been found upon occasion (Spencer 1973).

Larval feeding lasts from 9 to 11 days, while the pupal stage requires 9 or 10 days; the entire life cycle lasts from 16 to 26 days. Females normally mate within five days of emergence. In the laboratory, males fed on water barely lived from 10 to 46 days; females lived from 15 to 36 days (Spencer 1973).

### *M. dolichostigma*

Eggs are laid exclusively on the underside of the leaves and are frequently not inserted into the leaf tissue, but are merely deposited on the surface (van der Goot 1930). Feeding punctures are made on the upper side of the leaves. Three or four eggs may be laid together on a single leaf. Unfolded leaves are usually selected to prevent the eggs from falling before the larva hatches; hairs on the underside of the leaf also prevent the eggs from falling.

After hatching, the larva immediately eats its way into the leaf tissue and the nearest vein, and then moves into the stem via the petiole. It feeds initially on the outer layers, and, after feeding down the stem for 2 or 3 cm, turns and feeds upwards eating ever deeper into the pith. This produces a cavity that is covered only by the outer layers of the stem tissue and the epidermis. Lee (1976) reported that the larvae quickly mine to the stem apex after hatching, working their way down about 2 to 5 cm from the tip, and then start mining beneath the stem surface in a spiral direction. These spiral mines disturb the vascular tissue and result in the withering of the upper part of the stem. The larvae then feed in the withering tip. Pupation takes place in the damaged shoot, which dries and easily breaks by the time of pupation. The larvae do not make exit holes. As a rule only one maggot is found in a single damaged shoot.

The eggs hatch in about two days when average temperatures are about 28°C; the larval and pupal stages last about nine and six to eight days, respectively (at 25.5°C) (Lee 1976).

## Ecology

In an on-going study of the seasonality of *O. phaseoli*, *O. centrosematis*, and *M. sojae* in southern Taiwan, soybean was planted once every two weeks over a six-year period. The incidence of the three species was observed by sampling four-week-old plants once every two weeks (Talekar and Chen 1983). The results showed that agromyzid flies infest soybean practically throughout the year, but that infestation is most severe during the dry season (October - December). Almost all plants are damaged by the stem-feeding flies from October through December (Fig. 3). Lee (1976) in Taiwan and Kwon et al. (1980) in South Korea also observed heavy *Malanagromyza* infestation in the autumn season. Van der Goot (1930) reported greater infestation (*O. phaseoli*, *M. sojae*, and *M. dolichostigma*) in the dry season than in the wet season. The most likely explanation is that rainfall physically prevents feeding and oviposition. In Taiwan, although the dry season extends through April, insect infestation is considerably reduced in February and March, probably because of relatively cool temperatures from December through February. Abul-Nasr and Assem (1968) in Egypt and Morgan (1938) in Australia observed a reduction in beanfly infestation on crops planted during the winter months. Agarwal and Pandey (1961) found decreased *O. phaseoli* larval populations from the third week of December through the second week of February in northern India. They implied that the reduction was due to the presence of cooler weather when most of the larvae entered the pupal stage and became inactive. They also found reduced larval populations in May and June, a phenomenon which was attributed to extreme hot, dry weather, during which time the eggs failed to hatch and the flies survived as adults.

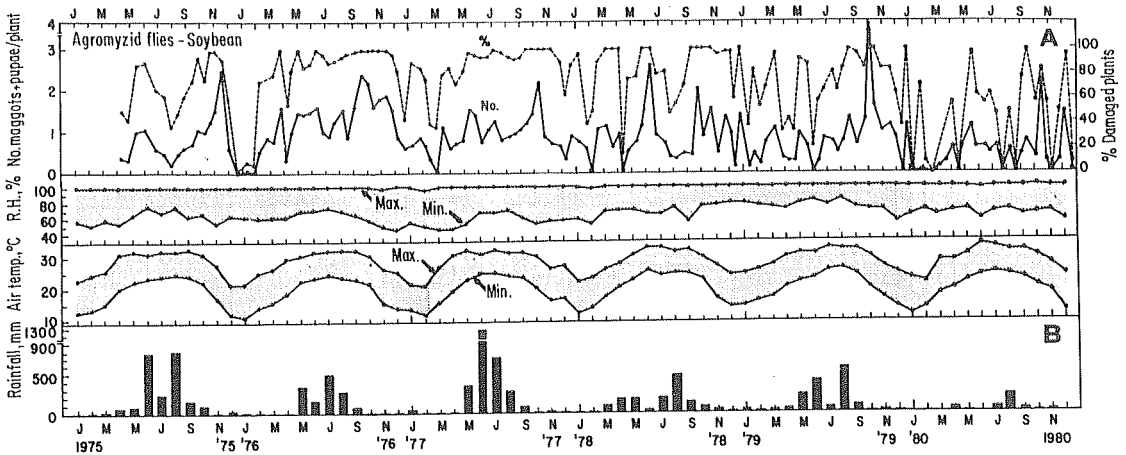


Fig. 3. Seasonality of beanflies, *O. phaseoli*, *O. centrosematis*, and *M. sojae* (A), and temperature, relative humidity, and rainfall (B), 1975-80 at AVRDC. Source: Talekar and Chen (1983).

## Damage

### Adult Feeding

The female flies, with the help of their ovipositors, puncture newly emerged leaves. In the case of *O. phaseoli*, the most prevalent strain in Indonesia, punctures are also made on soybean cotyledons. There are two types of punctures: Oviposition punctures and feeding punctures. Soon after the holes are made, the adult feeds on the sap that bleeds from the plant. Feeding on the sap that bleeds from ovipositional punctures is incidental to oviposition. The punctures create small, yellow, translucent, sunken windows in the leaf epidermis. This injury, however, does not significantly damage the plant.

### Larval Feeding

Major damage (reductions in plant growth and yield) results from the feeding of the beanfly larvae, especially on stem tissues.

### Feeding Sites

The larvae of the four beanfly species have distinct feeding sites (Fig. 4). *O. phaseoli* and *O. centrosematis* feed just beneath the stem epidermis up to the cortex. *O. phaseoli* feed and subsequently pupate in the main stem. *O. centrosematis* feeding can extend down to main root (Lee 1976). *M. sojae* feeds and pupates in the pith. All three species prefer young plants (cotyledons and early trifoliolate leaves). *M. dolichostigma*, on the other hand, feeds on the terminal parts of young growing shoots when the plants are at least three weeks old.

### Critical Damage Period

The importance of beanflies in the tropics lies in the fact that all species, especially those that feed in the main stem, prefer young plants. A biotype of *O. phaseoli* in Indonesia, for example, lays eggs in the cotyledons and kills the plants, presumably because of early infestation.

The critical protection period, especially for *M. sojae*, is about three to four weeks after germination (AVRDC 1979). Omethoate, an insecticide which is effective against beanflies, was sprayed once a week - for 9 weeks - beginning four days after germination. Infestation was monitored in 30 plant samples/plots at three and five weeks; yield was recorded at harvest. Seed yield increased with each of the first three sprays, but did not increase thereafter (Fig. 5). Because spraying was initiated when the plants were four days old, the critical period for beanfly protection would be about four weeks after germination.

*M. dolichostigma* infestation begins when the soybean plants are three to four week old, and the damage is visible two weeks later. By that time the plant is well established and is growing exponentially. *M. dolichostigma* prefers to infest luxuriously growing plants, and therefore does not cause significant yield losses (van der Goot 1930).

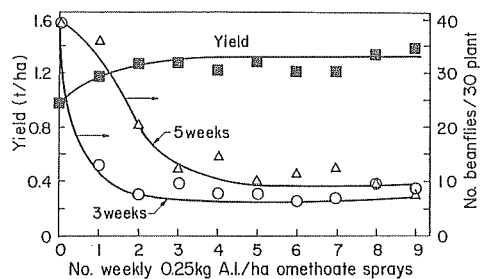
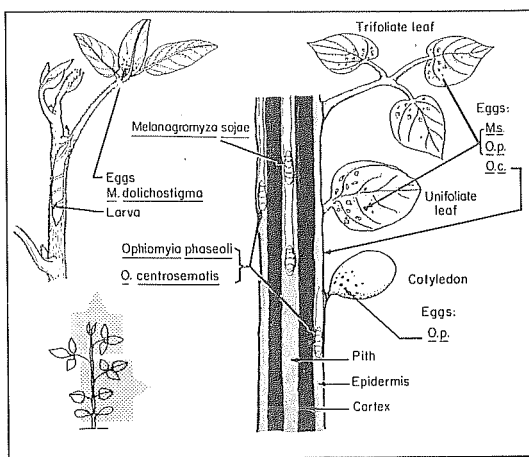


Fig. 4. (left) Oviposition, feeding, and pupation sites of various beanfly species in soybean.

Fig. 5. (above) Beanfly control and yield response of soybean to omethoate applications at various intervals.

### Damage Characteristics

The nature of the damage caused by *O. phaseoli* and *O. centrosematis* is practically identical, except that it is uncertain whether the latter insect lays its eggs in soybean cotyledons. Soybean is the least preferred host of *O. phaseoli* in the Philippines (Otanés 1918, Rajesus 1976) and Taiwan (Lee 1976, Chiang and Talekar 1980). However, it is particularly destructive in Indonesia (van der Goot 1930).

The larval mines on the cotyledons and unifoliate leaves are initially silver-white, but eventually turn brown. The tunnels extend into the petiole and stem. In slightly older plants the feeding tunnels on the stem are visible as black strips. When cut open, the larvae are found feeding just underneath the epidermis (van der Goot 1930). The number of larvae within each plant varies, but up to 31 were found in one 3-week-old plant at Palembang, Indonesia. As a result of infestation during the cotyledon stage, the plants succumb to the injury within a month after germination. The stronger plants can form new roots above the damaged parts, especially during the rainy season, while slightly damaged ones usually grow through the infestation without noticeable reductions in growth.

*M. sojae* is a pith feeder, and its damage in the stem is not visible except for a tiny exit hole which the adult uses to escape after the damage has already occurred. Feeding tunnels with larvae or pupae can be seen when the stems are cut open. Two separate tunnels are often present in slightly older, damaged

plants. Tunnels in the lower halves of the plants are older and are dark-brown in color. They originate roughly at the junction of the unifoliate leaf and extend downward to the soil surface, indicating that infestation results from eggs laid earlier in the unifoliate leaf. The second tunnel starts just under the top of the plant and extends downward to the first tunnel. In the event that the unifoliate leaf escapes infestation, the tunnel can extend up to the soil surface. This type of feeding occurs because of later infestation of the trifoliolate leaves. If the plant is damaged early, the later-infesting larvae may not have enough pith tissue to feed. In that case, the larvae gnaw upward, and produces a cavity in the top of the plant that results in the withering of the top; the lower part of the plant continues to grow.

Due to M. sojae's concealed feeding habit, its damage usually goes unnoticed. However, in controlled experiments where beanfly-free and infested plants are raised side by side, damage in the form of reduced plant growth is clearly visible. At AVRDC, one plot was maintained practically insect-free by applying insecticides near beanfly-infested plants. Observations of various plant characteristics were made soon after pod-set and at the onset of podborer infestation. M. sojae infestation significantly reduced plant height, number of branches/plant, number of trifoliolate leaves, leaf area/plant, and dry matter accumulation (Talekar 1980) (Table 1). The trifoliolate leaves of the infested plants were smaller than those of the insect-free plants.

The most characteristic signs of M. dolichostigma damage is wilting of the growing tip or tip withering. If tips are carefully examined, a spiral-shaped mine can be observed around the stem, 3 to 5 cm beneath the surface. The number of circles in the spiral varies from three to six; in rare cases the mine is neatly coiled but irregular in appearance. As the shoot wilts, the mine becomes increasingly inconspicuous (Lee 1976). As a result of the damage, the growing tip and plant growth is checked until the auxillary buds in the lower nodes develop into branches. This leads to abnormal branching in younger plants.

Table 1. Effect of beanfly (M. sojae) infestation on certain characters of soybean cv. GC 30067-0-8.

Plant Characteristics	Beanfly Protected <sup>z</sup>	Beanfly Infested
No. branches/plant	2.6**	1.2
Plant height (cm)	51.9**	41.8
No. trifoliolate leaves/plant	12.3**	9.0
Leaf area (cm <sup>2</sup> /plant)	1093.9**	423.8
Leaf area (cm <sup>2</sup> /trifoliolate leaf)	89.3**	47.1

<sup>z</sup> Plants were protected from beanfly infestation by frequent sprays of omethoate 50 EC. Damaged plants in protected area 6%; in infested area 99%

\*\* Difference between beanfly-protected and beanfly-infested significant the at 1% level by the student t test.

### Yield Loss

Total plant destruction usually occurs when O. phaseoli infests soybean, especially in the cotyledon stage. Van der Goot (1930) observed up to 100% plant mortality when the pest attacked seedlings. Up to 90% mortality has been recorded in Thailand. If infestation starts in the late seedling stage, yield losses in excess of 50% can be expected (Sepswasdi 1976).

M. sojae infests soybean in the unifoliate and early trifoliolate leaf stages, but infestation rarely results in plant death. Yield loss varies accord-

ing to location. In Taiwan, the loss among 163 soybean accessions was 31% (AVRDC 1981). Bhattacharjee (1980) reported that all but 5 of the 782 plants tested were attacked. He found a highly significant negative correlation between stem length injury and yield and stem length injury and plant height (Fig. 6). There was also a highly significant positive correlation between plant height and yield ( $r^2=0.61^{**}$ ).

M. dolichostigma damage, which is often highly visible, does not result in significant yield losses.

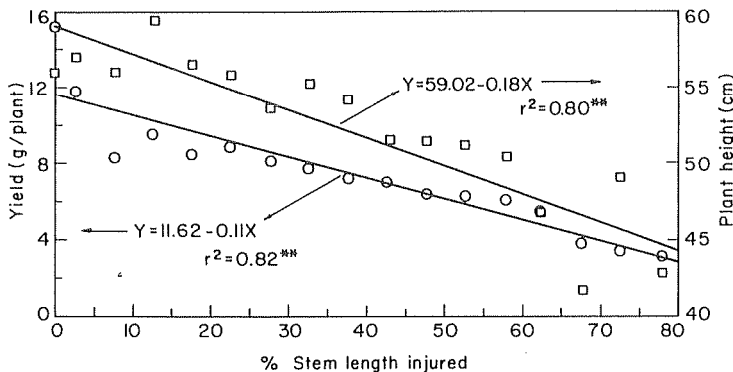


Fig. 6. Plant height and yield response in soybean as influenced by the degree of stem tunneling by M. sojae. Source: Bhattacharjee (1980).

### Control

Control measures vary according to location and season, but all emphasize the importance of protecting the plant in the seedling stage.

### Cultivar Resistance

Chan et al. (1967) screened 435 accessions for resistance to M. sojae. Accessions PI 56618, PI 88310, PI 227213, and PI 92748 had the least damage. Hsu et al. (1968) screened 137 cultivars for resistance to M. sojae, but found all entries to be susceptible.

Chiang and Talekar (1980) screened 6,775 soybean accessions over a two-year period, and in their final multilocal trial found four wild soybean accessions (G. soja) to be highly resistant to M. sojae (Table 2). Characterization of the resistance mechanism revealed that beanfly infestation is influenced during the early plant growth stage by the trichome density of the abaxial surface of the leaf, as well as by leaf area, leaf moisture content, and stem diameter. When the plant is in the V3 stage (or older), both leaf dry weight/cm<sup>2</sup> of the second trifoliolate and the stem moisture content of the internode between the second and third nodes are positively correlated with the level of beanfly infestation (Chiang and Norris 1983). Breeding is underway to incorporate the resistance of the wild accessions into agronomically acceptable cultivars.

Resistant accessions tested in Indonesia, where O. phaseoli is a major pest, all suffered heavy mortality rates. Efforts are therefore underway to screen the entire AVRDC soybean germplasm collection for resistance to O. phaseoli. Recent screenings in Indonesia revealed that of the 217 entries tested, 2 G. soja and 22 Neonotonia sp. accessions are tolerant. Average mortality was about 35% compared with 100% in the susceptible G. max checks.

Table 2. Response of selected AVRDC soybean accessions to beanflies<sup>z</sup> at six locations in Taiwan<sup>y</sup>.

Accession No.	No. Beanfly Larvae + Pupae/10 Plants --weeks after germination--	
	3	6
G 3089	0.4c <sup>x</sup>	2.7c
G 3091	0.3c	1.1c
G 3104	0.2c	0.5c
G 3122	0.6c	1.1c
G 286 <sup>w</sup>	12.0a	13.8b
G 3453 <sup>w</sup>	14.1a	16.2a

<sup>z</sup> Mainly M. sojae

<sup>y</sup> Combined analysis of three replicates at each location

<sup>x</sup> Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test

<sup>w</sup> Susceptible checks, G. max; first four entries G. soja

Source: Chiang and Talekar 1980

### Ridging

When soybean is attacked by O. phaseoli, the plant forms rows of adventitious roots on the stem above the root collar. Van der Goot (1930) tried to encourage the formation of new rootlets by earthing up young plants when adventitious root formation became visible, usually about three weeks after germination. Plants treated in this way reportedly suffered lower mortality rates than the control plants.

### Fertilization

Increases in soil fertility promote plant growth, and thereby help the plant to grow through the infestation. Van der Goot (1930) found a higher rate of plant mortality for crops grown on infertile soil (after paddy) than for plants grown on fertile soil (after Crotalaria).

### Mulching

Van der Goot (1930) also found significantly less plant mortality when soybean was covered with rice straw mulch (Table 3). The damage in the mulched fields was 44%, compared with 66% in bare fields. Similarly, plant mortality was 38% in the non-mulched fields as compared with only 17% in fields covered with rice straw.

The beneficial effect of rice straw mulch was initially believed to be due to moisture conservation that encouraged plants to grow vigorously, and thereby tolerate beanfly damage. However, mulched plants were found to be consistently less infested than non-mulched plants. This was due to the fact that the rice straw covers the germinating seedlings and cotyledons, thus preventing access for oviposition.

This practice does not prevent M. sojae infestation since the insect does not lay its eggs in cotyledons. In a large-scale experiment at AVRDC, straw mulch, rice stubble culture, plastic or aluminum foil mulch, and fish meal mulch failed to control M. sojae (AVRDC unpublished data). Therefore, it is also unlikely that mulching will control M. dolichostigma.

Table 3. Effect of rice straw mulch on beanfly control in soybean.

Treatment	Sowing Date	No. Plants	No. Damaged	No. Dead	Damaged (%)	Dead (%)
With straw	27-4-1919	999	427	63	42.7	6.3
Without straw	27-4-1919	1110	792	141	21.3	13.6
With straw	9-5-1919	1217	594	140	48.8	11.5
Without straw	9-5-1919	1159	632	162	53.6	13.1
With straw	9-5-1919	1384	786	117	56.7	8.4
Without straw	9-5-1919	1245	616	230	49.4	18.4
With straw	3-6-1919	883	348	196	39.7	22.1
Without straw	3-6-1919	799	470	166	58.8	20.7
With straw	3-6-1919	1137	346	260	30.3	22.8
Without straw	3-6-1919	937	593	589	63.6	63.1
With straw	7-11-1919	1475	547	47	64.2	3.1
Without straw	7-11-1919	1087	961	61	88.4	5.6
With straw	11-5-1920	1861	726	103	39.0	5.5
Without straw	11-5-1920	1628	972	319	59.7	19.5
With straw	21-8-1920	675	441	524	65.3	77.6
Without straw	21-8-1920	1246	1082	462	86.8	37.1
With straw	2-7-1921	586	275	176	47.0	30.1
Without straw	2-7-1921	585	406	275	69.4	46.6
With straw	16-7-1921	615	123	?	20.0	?
Without straw	16-7-1921	570	316	?	55.4	?
With straw	18-8-1921	436	298	134	68.3	30.7
Without straw	18-8-1921	561	414	561	73.8	100
Leaves of uri <sup>z</sup>	16-10-1922	563	227	44	40.3	7.8
Roots of uri <sup>y</sup>	16-10-1922	489	346	51	70.7	10.4
Without straw	16-10-1922	623	455	45	73.0	5.6

<sup>z</sup> Leaves of Imperata cylindrica

<sup>y</sup> Roots of Imperata cylindrica

Source: van der Goot (1930)

### Intercropping

Van der Goot (1930) found that intercropping soybean with eggplant and yam bean, a common practice among Javanese farmers, reduces beanfly infestation. He attributed this to the fact that the companion crop shades the soybean, thus reducing the insects' access to the plants.

In a trial at AVRDC, soybean was intercropped with 60 field crops, vegetables, green manure crops, or ornamentals (14 botanical families). Two rows of the companion crops were planted 60 cm apart, four weeks before the soybean was planted as a single row between the two intercropped rows. M. sojae infestation was evaluated four weeks after planting by cutting open 20 soybean plants/5 m row plot and recording the number of larvae and pupae found in the plants and the percentage of beanfly-damaged plants. None of the companion crops significantly affected beanfly infestation compared with the monocrop control (AVRDC unpublished data).

### Planting Date

Although beanflies are present in the tropics throughout the year, infestation varies from season to season. For example, van der Goot (1930) found that

without precautionary measures it was impossible to raise a soybean crop in Indonesia during the dry season. In the rainy season, plant mortality was significantly less even though the beanfly population was equal to that found in the drier months. This phenomenon is apparently related to plant vigor.

In Taiwan, beanflies are present throughout the year, but infestation is severe (100%) only from October through December. In the spring, infestation is relatively low and no control measures are required (AVRDC unpublished data).

Whether in Java or Taiwan, soybean planting dates are determined by the cropping system and not by insect pest infestation. The rainy seasons in Indonesia and Taiwan are the rice growing seasons, and despite insect pest problems, most soybean will continue to be planted during the dry season - the period when beanfly infestation is at its worst.

### Biological Control

Van der Goot (1930) and Greathead (1968) carried out fairly detailed studies on the biology and parasitism of various beanfly species. Most of the parasites were found to attack beanflies during the larval stage, but did not kill the host until the pupal stage. The parasitism of various beanfly species is shown in Table 4.

Although the existing rate of parasitism is high, sufficient numbers of flies survive to cause substantial damage; the parasites only reduce the level of infestation. Nevertheless, it may be useful to introduce parasites in some locations. One example is the successful introduction of two hymenopterous parasites (Opinus phaseoli and O. importatus), from Uganda to Hawaii in 1969. O. phaseoli was accidentally introduced a few years earlier and rapidly spread throughout the island chain (Davis 1970). The parasites were readily established on several islands, and significantly affected the O. phaseoli population.

### Chemical Control

Preventive and curative insecticides are commonly used to control beanflies in the tropics and subtropics. Because beanflies mainly attack young soybean plants, early insecticide application provides the best protection.

Prior to the introduction of synthetic insecticides, nicotine sulfate and derris dust were successfully used in Australia to control beanfly infestation in snapbean (Morgan 1938, Caldwell 1939). With the introduction of synthetic organic pesticides in the mid-1940s, a large number of chemicals were tested in the hope of controlling beanflies. In Java, 0.05% DDT or BHC at the rate of 800 l/ha or 5% DDT or BHC (15% gamma-isomer) dust at the rate of 15.2 kg/ha immediately after the soybean plants emerge, and repeated every other day up to seven days, provided satisfactory beanfly control (van der Laan 1949). Van der Laan's later experiments showed that taxophene (0.12% spray or 10% dust) provided better control than DDT or BHC.

Taylor (1959) in Australia and Walker (1960) in Tanzania achieved excellent beanfly control with aldrin, dieldrin, and endrin emulsions applied as seed dressing (0.2% a.i.). Organophosphorus insecticides such as parathion, diazinon, Dipterex, and malathion were shown to be less effective. In Sri Lanka, Wikramasinghe and Fernando (1962) also achieved good beanfly control by soaking seeds in aldrin, dieldrin, endrin, and chlordane.

The use of most organochlorine insecticide was either banned or restricted in the 1970s. An insecticide screening program was therefore initiated at AVRDC in 1974 to find an insecticide that provides satisfactory and economical control

of beanflies, mainly *M. sojae*. Of the 66 insecticides tested, only three (monocrotophos, dimethoate, and omethoate applied as 0.5 kg a.i./ha sprays after germination at 3, 7, 14, 21, and 28 days) provided consistent, satisfactory control. When applied as granules banded alongside the seeds at planting, none of the compounds controlled beanflies (Table 5). Apparently the chemicals control the insect by killing the adults that visit plants for oviposition and feeding. A study revealed that the three insecticides are structurally related organophosphorus compounds.

Table 4. Parasitism of various beanfly species.

Species	Parasite Species	Average Parasitism	Location	Reference
<i>O. phaseoli</i>	<i>Cynipoide</i> sp.	5%	Java	van der Goot 1930
	<i>Eurytomia poloni</i> Gir.			
	<i>Eurytoma</i> sp.			
	<i>Trigonogastra agromyza</i> Dodd.	17%	Philippines	Otanés 1918
	<i>Paratrigonogastra stella</i> Gir.			
	<i>E. poloni</i>	ineffective	Rhodesia	Jack 1912
	<i>A braconid</i>		Rhodesia	Taylor 1958
	<i>Opius liogaster</i> Szepl.	38%	Madagascar	Greathead 1968
	<i>O. melanagromyzae</i>	20%	Mauritius	Greathead 1968
	<i>O. melanagromyzae</i>	50%	Taiwan	Rose et al. 1976
	<i>Plutarchia</i> sp.	50-93%	Uganda	Greathead 1968
	<i>O. melanagromyzae</i>	3-9%	Uganda	Greathead 1968
	<i>Opius</i> sp.	<1%	Uganda	Greathead 1968
	<i>Norbanus</i> sp.	4-26%	Hawaii	Raros 1975
	<i>O. phaseoli</i>	0-26%	Hawaii	Raros 1975
<i>O. importus</i>				
	<i>Halticoptera patellana</i> Dalman			
	<i>Sphegigaster</i> sp.		Taiwan	Chu and Chou 1965
	<i>Opius</i> sp.		Taiwan	Chu and Chou 1965
	<i>Eucoilidea</i> sp.		Taiwan	Chu and Chou 1965
	<i>Eurytoma</i> sp.		Taiwan	Chu and Chou 1965
<i>O. phaseoli</i>	<i>Cryptoprymna</i> sp.		Taiwan	Chu and Chou 1965
	<i>Halticoptera</i> sp.		Taiwan	Chu and Chou 1965
<i>O. Centrosematis</i>	<i>Eucoilidea</i> sp.	20%	Uganda	Greathead 1968
	<i>Eurytoma</i> sp.		Taiwan	Chu and Chou 1965
	<i>Cryptoprymna</i> sp.		Taiwan	Chu and Chou 1965
	<i>Halticoptera</i> sp.		Taiwan	Chu and Chou 1965
	<i>Sphegigaster</i> sp.		Taiwan	Chu and Chou 1965
<i>M. sojae</i>	<i>Secodella</i> sp.	30-56%	Java	van der Goot 1930
	<i>Cynipoide</i> sp.			
	<i>Trigonogastra agromyzidae</i> Dodd.			
	<i>Eurytoma</i> sp.		Taiwan	Chu and Chou 1965
	<i>Eucoilidea</i> sp.		Taiwan	Chu and Chou 1965
	<i>Eurytoma</i> sp.		Taiwan	Chu and Chou 1965
	<i>Cryptoprymna</i> sp.		Taiwan	Chu and Chou 1965
	<i>Halticoptera</i> sp.		Taiwan	Chu and Chou 1965
	<i>Sphegigaster</i> sp.		Taiwan	Chu and Chou 1965
	<i>Stenomalina</i> sp.		Taiwan	Chu and Chou 1965
<i>M. dolichostigma</i>	<i>Secodella</i> sp.	10-47%	Java	van der Goot 1930
	<i>Cynipoide</i> sp.			
	<i>Eurytoma poloni</i> Gir.			
	<i>Trigonogastra agromyzidae</i> Dodd.			
	<i>Eurytoma</i> sp.			

Systemic insecticides (e.g. phorate and carbofuran), when banded along the seeds at sowing time, provided satisfactory control of *O. phaseoli* at other locations (Roongsook et al. 1973, Hussein 1978). However, these insecticides do not control beanflies at AVRDC. This could be due to the slightly alkaline pH of

AVRDC soil (pH 7.5 to 8). Organophosphorus and carbamate are degraded rapidly under alkaline conditions.

Table 5. Effect of mode of application of selected insecticides in the control of beanflies on soybean<sup>z,y,x</sup>.

Insecticide	kg a.i./ha	No. Maggots+Pupae/ 30 Plants	Damaged Plants (%)
Monocrotophos 2.5G	2.0	24.25a	85.825a
Dimethoate 2.5G	2.0	21.50a	82.525a
Omethoate 2.5G	2.0	21.00a	82.525a
Monocrotophos 55EC	0.5	2.00c	10.000d
Dimethoate 44EC	0.5	4.50c	25.850c
Omethoate 50EC	0.5	0.75c	4.175d
Control		22.75a	87.500a

<sup>z</sup> Insecticide granules (laboratory made) were applied alongside the seeds at planting. EC formulations were sprayed at 3, 7, 14, 21, and 28 days after germination

<sup>y</sup> Data shown are means of four replicates. Means in each vertical column followed by the same letter are not significantly different at the 5% level according to Duncan's Multiple Range Test

<sup>x</sup> Plot size = 10 m<sup>2</sup>

### Literature Cited

- Abul-Nasr, A. and M. A. H. Assem. 1966. Some ecological aspects concerning the bean-fly Melanagromyza phaseoli (Tryon). Bull. Soc. Entomol. Egypt 50:163-172.
- Abul-Nasr, A. and M. A. H. Assem. 1968. Studies on the biological processes of the beanfly, Melanagromyza phaseoli (Tryon). Bull. Soc. Entomol. Egypt 52:283-295.
- Agarwal, N. S. and N. D. Pandey. 1961. Bionomics of Melanagromyza phaseoli (Coq.) (Diptera:Agromyzidae). Indian J. Entomol. 23:293-298.
- Ali, A. M. 1957. On the bionomics and control of the beanfly, Agromyza phaseoli Coq. Bull. Soc. Entomol. Egypt 41:551-554.
- AVRDC. 1979. Progress Report for 1978, pp. 173. Asian Vegetable Research and Development Center, Shanhua, Taiwan.
- AVRDC. 1981. Progress Report for 1980, pp. 110. Asian Vegetable Research and Development Center, Shanhua, Taiwan.
- Bhattacharjee, N. S. 1980. Incidence of the stemfly, Ophiomyia phaseoli (Tryon) on soybean. Indian J. Entomol. 42:280-282.
- Caldwell, N. E. H. 1939. Beanfly control in southern Queensland. Queensland Agric. J. 52:393-396.
- Chan, K. L., H. B. Cheng, and H. H. Chen. 1967. Screening of soybean varieties for resistance to root and stem miners. Ann. Rep. Dryland Food Crops Improvement, pp. 176-178 (in Chinese).
- Chiang, H. S. and D. M. Norris. 1983. Morphological and physiological parameters of soybean resistance to agromyzid beanflies. Environ. Entomol. 12:260-265.

- Chiang, H. S. and N. S. Talekar. 1980. Identification of sources of resistance to the beanfly and two other agromyzid flies in soybean and mungbean. *J. Econ. Entomol.* 73:197-199.
- Chu, S. C. and L. Y. Chou. 1965. Survey on parasitoids of soybean miners. *Taiwan Agric. Res. Inst. Ann. Rep.* 1965. p. 96 (in Chinese).
- Davis, C. J. 1970. Recent introductions for biological control in Hawaii - XV. *Hawaiian Entomol. Soc. Proc.* 20:521-525.
- Greathead, D. J. 1968. A study in East Africa of beanflies (Diptera: Agromyzidae) affecting Phaseolus vulgaris and their natural enemies, with the description of new species of Melanagromyza Hend. *Bull. Entomol. Res.* 59:541-561.
- Hassan, A. S. 1947. The beanfly Agromyza phaseoli Coq. in Egypt. *Bull. Soc. Fouad I Entomol.* 31:217-224.
- Hsu, S. J., L. M. Shiau, and W. H. Lin. 1968. Resistance of soybean varieties to soybean stem borer (Melanagromyza sojae Zhnt). *Plant Protec. Bull.* 10:37-46 (in Chinese with English Summary).
- Hussein, M. Y. B. 1978. Soil application of granular carbofuran to control bean fly Ophiomyia phaseoli (Tryon). *Pertanika* 1:36-39.
- Jack, R. W. 1912. The bean stem maggot. *Rhodesian Agric. J.* 46:149-157.
- Kwon, S. H., K. H. Chung, Y. I. Lee, J. R. Kim, and J. Ryu. 1980. Response of soybean varieties and planting dates to the beanfly (Melanagromyza sp) damage. *Korean J. Breed.* 12:30-34.
- Lee, S. Y. 1976. Notes on some Agromyzid flies destructive to soybeans in Taiwan. *Formosan Sci.* 30:54-62.
- McIntyre, W. 1898. A serious bean pest at Gosford. *Agric. Gaz. N.S.W. (Australia)* 9:560-561.
- Morgan, W. L. 1938. For beanfly control use white oil-nicotine sulphate mixture. *Agric. Gaz. N.S.W. (Australia)* 49:22-24.
- Otanes, F. Q. 1918. The beanfly. *Philippines Agric.* 7:2-31.
- Raros, E. S. 1975. Bionomics of beanfly Ophiomyia phaseoli (Tryon) (Diptera:Agromyzidae), and its parasites in Hawaii (Ph.D. dissertation). Dept. of Entomology, Univ. of Hawaii.
- Rajesus, R. S. 1976. Insect pest diversity and succession in Asian soybeans. In: R. M. Goodman, ed. *Expanding the Use of Soybeans*, pp. 97-103, INTSOY Series No. 10. University of Illinois at Urbana-Champaign.
- Roongsook, D., T. Sitchawat, F. W. Knapp, and A. Tiemtaisong. 1973. The effect of phorate and malathion on beanfly control and yield of mungbean. *Thai. J. Agric. Sci.* 6:283-286.
- Rose, R. I., C. S. Lin, S. P. Kung, H. W. Kao, C. Y. Su, and C. Y. Chang. 1976. Beanflies and their control. In: R. M. Goodman, ed. *Expanding the Use of Soybeans*, pp. 169-171. INTSOY Series No. 10. University of Illinois at Urbana-Champaign.

- Rutherford, A. 1919. Pests of pulse crops. *Trop. Agric.* 42:411-413.
- Sepswasdi, P. 1976. Control of soybean insect pests in Thailand. In: R. M. Goodman, ed. *Expanding the Use of Soybeans*, pp. 104-107. INTSOY Series No. 10. University of Illinois at Urbana-Champaign.
- Spencer, K. A. 1973. *Agromyzidae (Diptera) of Economic Importance*. W. Junk B. V., The Hague.
- Talekar, N. S. 1980. Search for beanfly resistance in soybean, mungbean, and snapbean. In: *Processing of Legumes in the Tropics*, pp. 293-295. Faculty of Agriculture, Universiti Pertanian Malaysia, Serdang, Selangor, Malaysia.
- Talekar, N. S. and B. S. Chen. 1983. Seasonality of insect pests of soybean and mungbean in Taiwan. *J. Econ. Entomol.* 75:3437.
- Taylor, C. E. 1958. The bean stem maggot. *Rhodesian Agric. J.* 55:634-636.
- Taylor, C. E. 1959. Control of bean stem maggots by insecticidal dressing. *Rhodesia Agric. J.* 56:195-196.
- van der Goot, P. 1930. *Agromyzid flies of some native legume crops in Java* Tropical Vegetable Information Service, Asian Vegetable Research and Development Center, Shanhua, Taiwan (translated from Dutch).
- van der Laan, P.A. 1949. Over de bestrijding van het katjangvliegje op kedelee met insecticiden. *Meded. Inst. Plantenz. Buitenzorg* No. 109, p. 28.
- Walker, P. T. 1960. Insecticide studies on East African agricultural pests III. Seed dressings for the control of the beanfly, Melanagromyza phaseoli (Coq.). Tanganyika. *Bull. Entomol Res.* 50:781-793.
- Wang, C. L. 1979. Occurrence and life history of Melanagromyza sojae on soybean. *J. Agric. Res. China.* 28:217-223 (in Chinese with English Summary).
- Wikramasinghe, N. and H. E. Fernando. 1962. Investigations on the insecticidal seed dressings, soil treatments, and foliar sprays for the control of Melanagromyza phaseoli (Tryon). *Ceylon. Bull. Entomol. Res.* 53:223-240.