CHEMICAL CONTROL OF SOYBEAN INSECT PESTS IN BRAZIL

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Abstract

Much of the increasing use of insecticides in Brazil has been due to the booming expansion in soybean acreage. Currently three regions of soybean production can be distinguished: (i) the traditional southern region; (ii) the expanding region of Central Brazil, and (iii) the potential area of flat lands of Northern Brazil. In 1982, 80.4% of all soybeans were produced in the traditional region and 19.5% in the expanding region. The major pests causing damage to soybeans are: velvetbean caterpillar (*Anticarsia gemmatalis*); stem borer (*Epinotia aporema*); and stink bugs (*Nezara viridula, Piezodorus guildinii*, and *Euschistus heros*). These three pests are responsible for more than 90% of the total insecticides used on soybeans. Brazil's 8.2 million hectares, with a production of 13 million tons of soybean, are responsible for a considerable share of the 72.3 thousand tons of insecticides sold in 1981. In general, soybean growers used to apply insecticides four or five times each season, representing a significant addition to the cost of production and environmental pollution. As a result, research on integrated pest management (IPM) and biological control methods have received high priorities in recent years. Based on IPM studies, the number of insecticide applications necessary for the pest control was reduced from five to two, with an overall saving of 58.4%. For the State of Parana alone, over a period of three years, it represented a saving of 93.8 million liters of diesel fuel, 13.35 million liters of insecticides and an economy of US$132.5 million. With several million hectares of untouched land presently included in the government's plan for future soybean production in the expanding and potential regions, the future demand for insecticides in Brazil will certainly be increased.

The soybean situation in Brazil

Following a sharp increase from 1970 to 1980, expansion of soybean acreage has stabilized in the past three years. From less than 1.5 million in 1970, the production jumped to 15.5 million tons in 1980, increasing at an average rate of one million tons per year (Table 1) (IBE, FGV, 1970/80; Safras e Mercados, 1980/82). In 1978/79 and 1982 the production was lower due to severe drought.

Currently three regions of soybean production can be distinguished in Brazil: (i) the traditional Southern region represented by the States of Parana (PR), São Paulo (SP), Santa Catarina (SC) and Rio Grande do Sul (RS); (ii) the expanding region of Central Brazil, represented by the States of Goiás (GO) (South), South Mato Grosso (MS), South of Mato Grosso (Northern state) (MT) and Minas Gerais (MG); and (iii) the potential soybean production area of Central Mato Grosso (MT), North of Goiás (GO), Maranhão (MA) and Piauí (PI) (Fig. 1).

In the traditional region, the future increase in production will depend more on higher yield and refinement of production technology than on increase in acreage. Sugarcane plantations, mainly for fuel alcohol, and diversification of crops (corn and sunflower) are requiring whatever land is available, thus limiting soybean expansion. In 1970 the traditional region was responsible for 98.6% of the total amount of soybeans produced in the country but in 1982 it decreased to 80.4% (Table 1). Soybean production in this area is most mechanized and although the chemical method is still the most important insect control measure, pest management and biological control methods are more routinely used.

In the expanding region of Central Brazil, soybean is steadily gaining in importance (Table 1).

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Table 1 Evolution of soybean production in the traditional (South) and expanding (Central) regions of Brazil.*

	1970	1975	1978	1980	1981	1982
Traditional Region (South)						
Area (1,000 ha)	1,303.5	5,497.7	7,070.1	7,478.7	7,206.0	6,653.0
Production (1,000 t)	1,488.0	9,459.0	8,818.0	12,964.0	13,003.0	10,458.0
Yield (kg/ha)	1,141.0	1,720.0	1,247.0	1,733.0	1,800.0	1,635.0
of total production (%)	98.6	95.6	92.5	85.5	83.9	80.4
Expanding Region (Central)						
Area (1,000 ha)	15.3	325.9	708.3	1,283.1	1,430.0	1,572.0
Production (1,000 t)	20.6	433.4	716.6	2,178.0	2,497.0	2,537.0
Yield (kg/ha)	1,350.0	1,329.0	1,012.0	1,698.0	1,750.0	1,619.0
of total production (%)	1.4	4.4	7.5	14.4	16.1	19.5
Total area	1,318.8	5,823.7	7,778.4	8,761.8	8,636.0	8,225.0
Total production (1,000 t)	1,508.6	9,892.4	9,534.6	15,142.0	15,500.0	12,995.0

* Source: IBE, FGV, 1970–80; Safras e Mercados, 1980 and 1982.

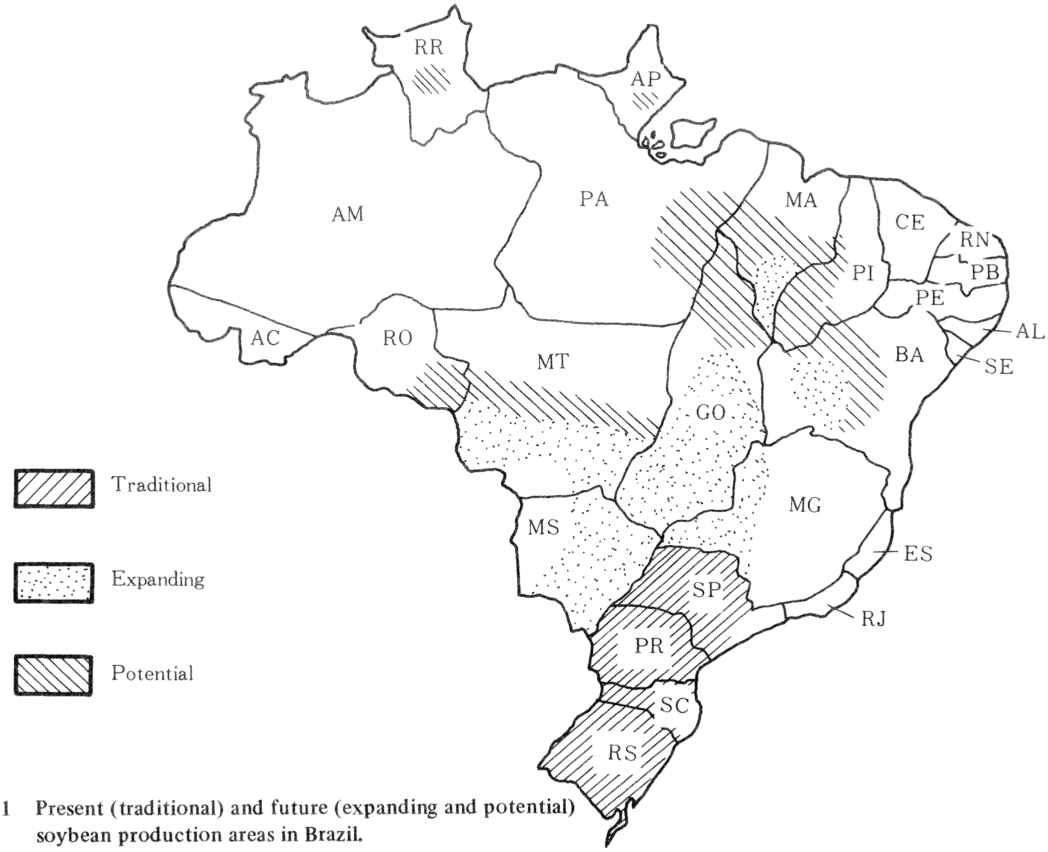

Fig. 1 Present (traditional) and future (expanding and potential) soybean production areas in Brazil.

In 1970 the region was responsible for only 1.4% of the national production, but in 1982 it rose to 19.5%. Most of the farms are larger than those in the South, more prone to mechanization and pest control is mostly done by chemical means.

In the potential region of Northern Brazil, soybean production is still in the exploratory stage but seems to hold a great future. Recent results obtained by an outreach program of the National Soybean Research Center have shown that yields of adapted varieties can be as high as those of the South. Several million hectares of untouched land are presently included in the government's plan for future crop production in the expanding and potential areas. This will certainly bring new demand for pesticides, especially insecticides and herbicides.

Soybean insect pest control

The use of chemicals for soybean insect control in Brazil has been affected by a number of factors over the years. To a large extent, much of the increasing use of insecticides has been due to the booming expansion of the cultivated area in the past (Table 1).

In general, soybean growers in Brazil used to apply insecticides four or five times each season, representing a significant increase in the cost of production. Most of the 72.3 thousand tons of insecticides sold in 1981 was used on soybeans (ANDEF/SINDAG, 1982).

The criteria generally followed by the farmers to decide whether or not to apply insecticides were: (i) preventive application even when no pests were detected and following applications at pre-established intervals; (ii) application of insecticides when the first insects were observed on soybeans and subsequent applications at pre-established intervals and (iii) application of greater or lesser amount based on the availability of the chemicals and price of the products.

Frequently, treatments based on farmer's judgement resulted in excess of pesticides and environmental pollution. Inappropriate chemicals are often used for a specific pest, resulting in partial or total loss of investment. Also the application of a broad-spectrum insecticide may be causing the disruption of the ecological balance and favoring the pests (Panizzi *et al.*, 1977).

It is not uncommon to find farmers who have neglected to inspect the soybean fields, especially for stink bugs and end up applying insecticides when the damage had been completed.

Some of the reasons for the excessive use of insecticides could be pointed out as (i) the pressure exercised by sale agents and mass advertisement; (ii) lack of accounting by the farmer to assess the cost/benefit ratio regarding pesticide application; (iii) the easy access toward subsidized agricultural credit for pesticides; in 1980, 25.87% of all credit for pesticides was allocated to insecticides and herbicides for soybeans (Banco Central do Brasil, 1980), (iv) lack of knowledge by many farmers about the economic damage threshold levels for the different kinds of pests; and (vi) lack of information about the pest management program in many soybean growing areas due to the absence of an active extension service.

Water and environmental pollution by insecticides resulting in death of farm and wild animals, birds, fishes and occasional human casualties are serious problems during the height of cotton and soybean season (Streitemberger *et al.,* 1977). Public and government awareness of the harmful effects of pesticides has resulted in a new law regulating the registration and use of agricultural chemicals (MA, 1980). In an attempt to minimize the harmful effects of pesticides, research on integrated pest management (IPM) and biological control methods have received high priority. These methods are now routinely used by many soybean growers in the South.

The major pests causing damage to soybeans in Brazil are: (i) velvetbean caterpillar (*Anticarsia gemmatalis*) (Hübner); stem borer (*Epinotia aporema* Walshigham) and stink bugs (*Nezara viridula* L., *Piezodorus guildinii* Westwood), and more than 90% of total insecticides are used on soybean in Brazil (Oliveira *et al.*, 1980). Few others may have localized outbreaks and may require occasional insecticide treatments.

Studies on pest management have shown that, under natural conditions, the populations of most insect pests tend to decrease before they reach the economic threshold level, remaining at low levels until the end of the season (Panizzi *et al.*, 1977). But when a broad-spectrum insecticide is used early in the season, when insect pests are beginning to appear, it may cause a greater resurgence of pests. The peak of insect population, following an insecticide application may occur later than that of a natural population (Figs. 2 and 3).

Usually the resurgence occurs when the soybean plants are in the reproductive stage and, therefore, causes greater damage. Thus preventive application of insecticides, besides being a waste of chemicals and added cost of production, also eliminates the potential benefit of natural biological control (Figs. 2 and 3) (Panizzi *et al.*, 1977).

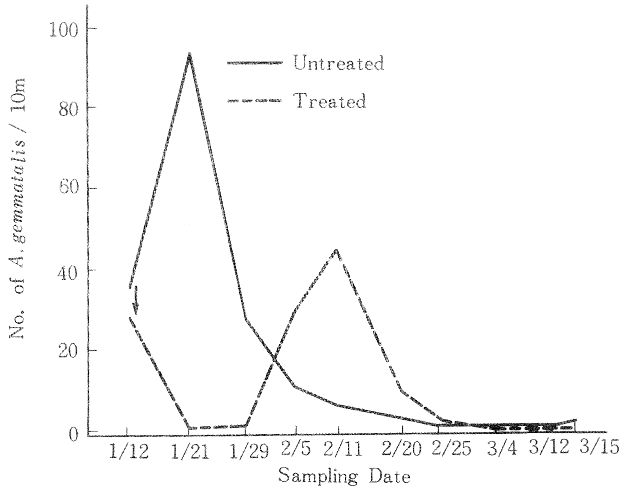

Fig. 2 Population curves of *Anticarsia gemmatalis* in insecticide-treated and untreated plots. Arrow indicates date of treatment (Panizzi *et al.*, 1977).

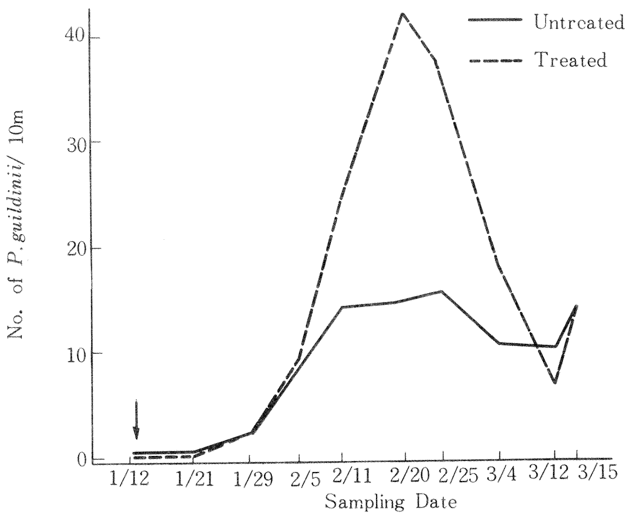

Fig. 3 Population curves of *Piezodorus guildinii* in insecticide-treated and untreated plots. Arrow indicates date of treatment (Panizzi *et al.*, 1977).

In the IPM approach, all possible pest control mechanisms (chemical and biological methods) available to the farmers are concurrently used and specific pesticides are applied at proper timing. The biology of the major insect pests occurring in the main production areas of Brazil is also well understood (Gazzoni *et al.*, 1981).

From the IPM studies it was possible to establish the economic threshold level for leaf feeders and stink bugs and to determine the proper time for action. The insecticides that are recommended are less toxic, have low residual effect, are specific to the target pest, have little effect against the natural enemies and are degraded faster than other chemicals. IPM has some drawbacks in that it requires more attention from the farmer to inspect his bean fields, but, on the other hand, it has the advantage of forcing the farmer to become acquainted and follow the problems that were not noticed before (Oliveira *et al.*, 1980).

In the past several years the outbreak of two diseases of soybean caterpillar (*Anticarsia gemmatalis* and *Pseudoplusia includens*) caused by a fungus (*Nomuraea rileyi*) and a nuclear polyhedrosis virus (*Baculovirus anticarsia*) have greatly reduced the use of insecticides to control these pests (Ferreira, 1980). In addition to the entomopathogenic microorganisms, at least 29 parasites (Ferreira, 1978) and about the same number of predators (Gazzoni *et al.*, 1981) have been found to naturally affect the population of soybean insect pests.

Since the pest management program was initiated in Southern Brazil in 1974, with the involvement of the extension service, an increasing number of farmers have adopted a systematic use of this approach. This is particularly evident in the State of Parana. Based on a joint effort between research and extension services, a number of demonstration fields were established every year for training the farmers on the principles and practices of pest management and biological control. In addition, several training courses on pest management and adequate use of spray equipment were held at state and regional levels involving all extension workers of private enterprises and the cooperatives in the state (Finardi and Souza, 1980). At present, except for a few states, the extension service is very much lacking in personnel and efficiency, particularly in the expanding region of Central Brazil, and pest control is still largely dependent upon the farmer's judgement.

Studies to compare the cost/benefit between the farmer's normal procedures and those recommended by research have shown a significant reduction in cost of pest control by IPM (Table 2). The number of applications necessary for insect control was reduced from five to two with the cost being reduced from US$33.06/ha (farmer's method) to US$13.74/ha (IPM), representing a saving of US$19.32/ha) or 58.4% (Oliveira *et al.*, 1980). Considering the soybean

Table 2 Comparative cost/benefit between the farmer's soybean insect control method and the pest management approach recommended by EMBRAPA. Crop year 1979/80.*

Items compared	Unit	Farmer's method (5 applications) A		Pest management (2 applications) B		Saving A – B	
		Amount	US$/ha	Amount	US$/ha	Amount	US$/ha
Tractor and equipment	h/ha	3.33	12.31	1.30	4.92	2.00	7.39
Fuel cost (diesel)	l/ha	20.00	6.00	8.00	2.40	12.00	3.60
Insecticides	kg or l/ha	1.90	14.75	0.80	6.42	1.08	8.33
Total			33.06		13.74		19.32

* Adapted from Oliveira *et al.*, 1980.

acreage of 8.5 million hectares in Brazil in 1979, and assuming that all the farmers used the IPM procedure, it would represent a saving of US$165 million directly to the farmers. The sum represents more than 25 times the fund spent by the National Soybean Research Center (CNPSoja) during the period from 1975 to 1979 (Oliveira *et al.,* 1980).

A study carried out by the extension service in the State of Parana during three soybean seasons (1977/78 to 1979/80) involving 21,911 farmers resulted in a reduction of 75.9% in the average number of pesticide applications. It represented a saving of US$71.1 million with a reduction in 24.5 million liters of diesel fuel and 3.5 million liters of insecticides. This was accomplished with the involvement of 128 extension agents in the three-year period with an average of 40.2% of their working time (Finardi and Souza, 1980).

From the above study and based on an assessment made by the extension service in the State of Parana, it was found that, from an average of 5.8 applications per crop season in 1976/1977, there was a decrease to 2.4 applications in 1979/80 (Finardi and Souza, 1980). For the three-year period, this represented an overall saving for the State of Parana of 93.8 million liters of diesel fuel and 13.35 million liters of insecticides. In terms of economy it provided a total saving of approximately US$28.1 million for fuel and US$104.4 million for insecticides, totalling US$132.53 million (Cr$:US$ = 40:1) (Finardi and Souza, 1980).

According to the new regulations established by the Ministry of Agriculture (MA, 1980) the recommendations of pesticides are specific to the crop and target pests and must be followed by the correct identification of the pest to be controlled. Each insect species may have different levels of tolerance or resistance to a particular chemical. Based on joint studies carried out by several official research institutions in Brazil, it has been possible to identify those chemicals and dosages that are efficient to specific pests and safer to the natural enemies (Table 3). Some of the prerequisites that must be fulfilled by the chemicals to be used are: (i) at the recommended dosage a chemical should control from 80 to 90% of the target pests; (ii) it should have a residual effect of 10–15 days; (iii) must be selective to most natural enemies present in a soybean field; (iv) should not have serious toxicological restrictions; (v) use must be economically feasible, and (vi) should not be present in the grain above the maximum tolerance level. Chemicals have also been classified into preferential (P) and optional (O), based on their effect on insect pests, natural enemies, the DL_{50} level, the toxicological class (Table 4), price, and those that can easily be applied with the available equipment (Gazzoni *et al.,* 1981).

The present recommendation for soybean insect pest control in most states is aimed at helping the users of the pest management program to decide which insecticide to apply in order to maintain the insect population below the economic threshold level. Other insecticides, though efficient in controlling the pests but lacking some fundamental prerequisites such as low toxicity for animals and natural enemies are not encouraged. Nevertheless, they may be used by the farmer if cleared by the Division of Phytosanitary Products (DIPROF) of the Ministry of Agriculture (MA, 1980).

Whenever possible, the chemicals that have lower toxicity to natural enemies should be used during the earlier stage of crop growth in order to assure the establishment of a minimum population of natural enemies (Gazzoni *et al.,* 1981).

In certain areas, in addition to the IPM, the use of insecticides on soybeans has been affected by a recent trend to sow soybeans much earlier. A few years ago, most of the soybeans in the State of Parana were sown from the month of November to the first week of December. The varieties grown were distributed among early- to late-maturing groups. In the past three to four years there has been a drastic change into planting soybeans between October 15 to November 15 and mostly with early-maturing varieties. Varieties of mid-maturing groups have decreased considerably and late-maturing groups are becoming rare. This change has led to a significant decrease in the use of insecticides, particularly for the stink bugs that used to cause serious damage to late-sown or late-maturing soybeans.

Table 3 Insecticides recommended for the soybean pest management program, their initial efficiency (i.e.) on target pests and on natural enemies (e.n.e.); crop season 1981/82. EMBRAPA/CNPSo, Londrina, PR.*

Insecticides (Common name)	Target pests											
	Anticarsia gemmatalis		*Pseudoplusia includens*		*Epinotia aporema*		*Nezara viridula*		*Piezodorus guildinii*		*Euschistus heros*	
	i.e.[a]	e.n.e.[b]	i.e.	e.n.e.	i.e.	e.n.e.	i.e.	e.n.e.	i.e.	e.n.e.	i.e.	e.n.e.
Azinphos-ethyl	85	2										
B. thuringiensis	90	1										
Carbaryl	85–95	1	80	1					80–85	1		
Chlorpyriphos-ethyl	80–95	2	85	2	90–95	3						
Diflubenzuron	85–90	1										
Dimethoate							80–85	3				
Endosulfan	85–90	1	85	1			85–95	1	85–90	1	85–90	1
Fenitrothion	85–90	2			80–85	4	85–90	3				
Parathion-methyl	80–90	2	80	3	80–90		80–85	4			80–85	4
Methomyl												
Monocrotophos	85–90	2	85	3	85–95	4	80–90	4	80–90	4	80–90	4
Omethoate	80–90	3					80–85	4	80–85	4	80–85	4
Phenthoate					85–90	3						
Phosalone	85	1										
Phosphamidon	90	2					90–95	3	90–95	3	90–95	3
Triazophos	85–95	1			80–85	2						
Trichlorfon	85–90	1					80–85	1	80–85	1	80–85	1

* Adapted from Gazzoni *et al.*, 1981.
a Initial effects: mortality 1–4 days after application;
b Effect on natural enemies: 1 = 0–20%, 2 = 21–40%, 3 = 41–60%, 4 = 61–80% and 5 = 81–100% mortality.

Table 4 **Insecticides recommended for the soybean pest management program: dosage (g of active ingredient/ha) for the target pests, pre-harvest interval, toxicity and toxicological class; crop season 1981/82. EMBRAPA/CNPSo, Londrina, 1981.***

Insecticides (Cammon name)	Target pests and dosage (g of a.i./ha)						Residual effect (days)[a]	Toxicity DL_{50} [b]		Toxico-logical class[c]
	Anticarsia gemmatalis	*Pseudo-plusia includens*	*Epinotia aporema*	*Euschistus heros*	*Nezara viridula*	*Piezodorus guildinii*		O	D	
Azinphos-ethyl	400 (O)[d]						10	14	250	I
B. thuringiensis	500pc./ha(O)						10	–	–	IV
Carbaryl	200 (P)[e]	320[a] (P)				800 (O)	10–15	590	2,166	III
Chlorpyriphos-ethyl	180	360 (O)	600 (P)				15	437	1,400	II
Diflubenzuron	25 (P)						30–40	4,640	2,000	IV
Dimethoate					750 (O)			–	–	II
Endosulfan	175 (P)	437 (P)		437 (P)	525 (P)	437 (P)	25–30	173	368	II
Fenitrothion	500 (O)		1,000 (O)		500 (O)		15	384	2,233	III
Parathion-methyl	200 (O)	300[a] (O)	480 (O)	480 (O)	480 (O)		10–15	15	67	I
Methomyl		350[a] (O)						–	–	I
Monocrotophos	150 (O)	300[a] (O)	500 (O)	300 (O)	300 (O)	300 (O)	15–20	19	323	I
Omethoate	500 (O)			750 (O)	750 (O)	750 (O)	10–15	65	875	II
Phenthoate			1,000 (O)					276	1,100	II
Phosalone	525 (O)						15	185	1,063	II
Phosphamidon	250 (O)			600 (O)	600 (O)	600 (O)	10–15	25	361	I
Triazophos	200 (O)		600 (O)				10–15	161	1,100	II
Trichlorfon	400 (P)			600 (O)	800 (P)	800 (P)	10–15	580	2,266	III

* Adapted from Gazzoni *et al.*, 1981.
[a]Pre-harvest interval: May depend on weather conditions during and after application, growth stage of the plant and type of insect. [b]0 = oral and D = dermal.
[c]Toxicological class: I = highly toxic (oral DL_{50} = 0–50), II = moderately toxic (oral DL_{50} = 50–500). III = low toxicity (oral DL_{50} = 500–5,000), IV = not toxic (oral DL_{50} > 5,000 mg/kg). [d]and [e](O): optional, (P): preferential.

In addition to the direct benefit to the farmer's income, a series of additional benefits could result from the general application of IPM: reduction in the price of soybean with benefit to the consumer and the society as a whole; economy in transportation with reduction in the use of insecticides, fuel and lubricants; reduction of toxic residues in the soil and marketable soybeans; maintenance of ecological balance (predators + parasites/pests relationship); reduction of human and animal poisoning, and less environmental pollution.

A national effort is under way to promote the pest management program and the biological control for the major crops, but soybean insect control by chemical means will be the most important weapon against insect damage for many years to come. While soybean production has stabilized in the traditional South, it is quickly expanding to new areas, especially to the savanna region of Central Brazil. Extension service is very much lacking in the region and the predominantly larger farms, mostly of several hundred hectares, usually require aircraft for insecticide application. Monitoring the insect population in such a vast area is not an easy task, and most farmers are not prepared for this.

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Discussion

Ishikura, H. (Japan): 1. You mentioned the occurrence of pest resurgence after the application of pesticides. What kind of pesticides did you use for soybean control? 2. In Japan, pesticides are usually applied at the later stages of growth of soybean, in particular after pod formation. Why did you apply insecticides at the early stage of growth of the plant? This may have promoted the occurrence of resurgence. 3. Do you carry out studies on proper timing of pesticide application? 4. How many generations do the stink bug and caterpillar undergo during the growth duration of soybean?

Answer: 1. When the studies on resurgence were carried out the farmers used to apply preventively several highly toxic pesticides to the natural enemies such as fenitrothion, methyl-parathion, monocrotophos, omethoate and phosphamidon. In Brazil preferential pesticides are endosulfan which exerts a minimum effect on the natural enemies as well as carbaryl. When these pesticides are not available, optional ones may be used by the farmers. 2. In Brazil early application of insecticides may be necessary to control the leaf feeder which causes damage approximately at the flowering time of the plant. 3. Yes, we do. Pesticide application is based on the economic threshold level of the damage for each pesticide and related to the growth stage of the plant. 4. I shall send you this information after I return to Brazil.

Thyagarajan, G. (India): Could you indicate the name of the predator that feeds on the stink bug?

Answer: You may find a list of predators and natural enemies in the manuscript.