Integrated Control of Soybean Stink Bugs in the Cerrados

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In order to promote successfully soybean production in the Cerrados of Brazil under adverse environmental conditions, a technique to obtain stable high yields at a low cost must be established. For this purpose, a study on an integrated control of soybean stink bugs was carried out. The study consisted of biological control, using natural enemies introduced from Japan to encourage the native natural enemies composed of a large number of species with a high population density under the natural ecosystem of the Cerrados, and agronomic control with the use of early maturing varieties and trap varieties of soybeans, to reduce the amount of insecticide application.

The study*** was carried out during two years from August, 1983 to September, 1985 in CPAC.

Investigation on population densities of major insect pests and their natural enemies in soybean fields of the Cerrados

To obtain basic data to establish a key pest management strategy, a field investigation on population densities of major soybean insect pests and their natural enemies was conducted in the soybean fields in the districts where the first project for the Cerrado development was implemented and the districts where the second project for the Cerrado development is to be carried out.

The investigation was conducted from February to May, 1985, in CPAC and other localities in Brasilia DF, Barreiras area of Bahia State, Mato Grosso State and State of Mato Grosso do Sul. In the investigation, soybean stink bugs with a size of more than 5 mm, their egg masses, larvae of Lepidopterous pests with a size of more than 15 mm, Chrysomelid pests, and their natural enemies were collected in four to thirty locations in each field investigated, and their population densities per square meter were calculated. Also, the percentage parasitism by egg parasites of the stink bugs was determined after the egg masses had been kept in the laboratory for a month. The result was as follows:

The population densities of the phytophagous insect pests were very low, while the number of species of their natural enemies was large and the population density was comparatively high, in the natural ecosystem of the Cerrados. However, the population density of the soybean stink bugs which was comparatively high in soybean fields, was beyond the economic injury level[1] (2 and 4 individuals with a size of more than 5 mm per m^2 in the fields for seed soybeans and processing soybeans, respectively) in about 20% of the total fields investigated. Based on this observation, the stink bugs were considered to be the most harmful group among the soybean insect pests, which occur constantly and prevalently. On the other hand, the population density of the Lepidopterous insect pests was much lower than the economic injury level[1] (40 individuals with a size of more than 15 mm per m^2). However, migratory Noctuids were considered to be the second

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*** A part of the study was briefly reported,[3,4,6,7] and the detail will be reported by the same authors from JICA in the near future.[8]

most injurious group among the soybean insect pests, which cause sudden and local outbreaks.

An interesting fact that migratory Noctuids, stink bugs and specific Chrysomelids start to attack soybeans, one or two years, three or four years and five or six years, after the onset of soybean cultivation, respectively was recognized.

As another interesting fact, the soybean stink bug association was recognized to change with years after soybeans began to be cultivated. That is, although the soybean stink bug association is the Cerrado type which consists of *Euschistus, Acrosternum,* etc. at first, it gradually changes into that of a crop field type in which *Nezara, Piezodorus*, etc. were dominant. The turning point may occur about five years or more after the beginning of soybean cultivation.

Insecticide application has generally been carried out twice or so in a season. In the area where insecticides have been applied more than two times, the percentage parasitism by egg parasites of stink bugs was extremely low, as shown in Fig. 1. In many cases, insecticides were applied in a condition where the population density of the insect pests was below the economic injury threshold. Therefore, adequate guidance is desirable.

Average yields of soybeans in farmer's fields were slightly beyond the economic yield threshold. Considering the risks involved, for example, the weather condition, depreciation of soybean price, etc. it was considered necessary to establish, as early as possible, a technique that insures stable high yields at low cost.

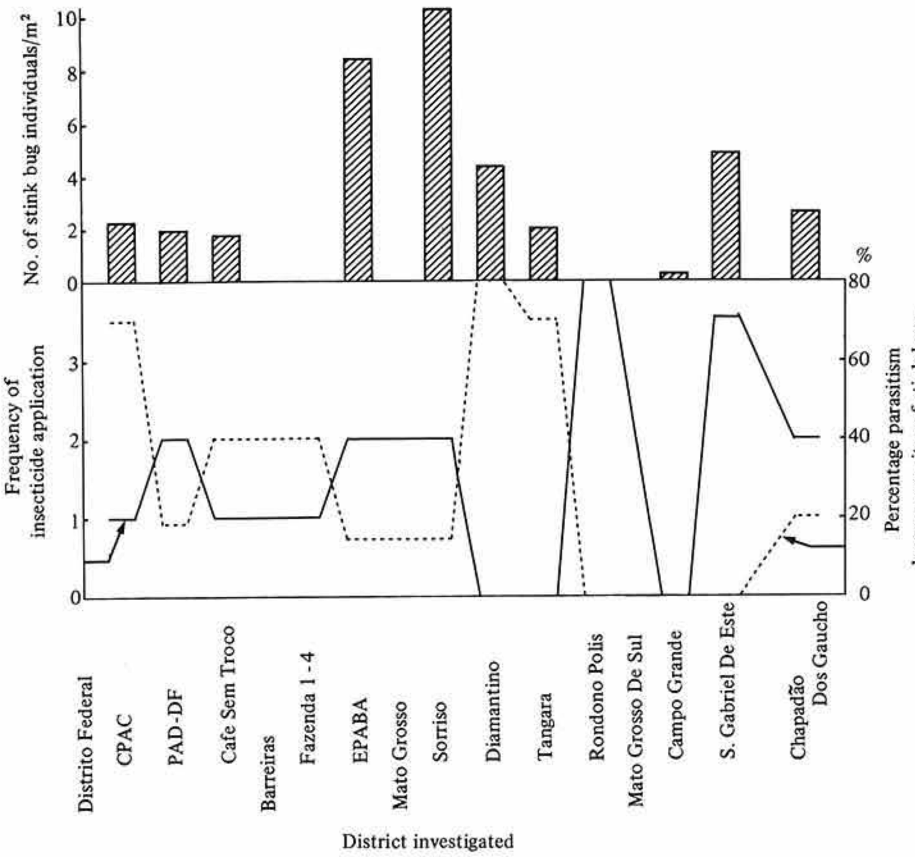

Fig. 1. Population density of soybean stink bugs, percentage parasitism by egg parasites of soybean stink bugs, and frequency of insecticide application observed on farmers fields

Introduction, biological studies, and the utilization of egg parasites for the control of soybean stink bugs

In order to establish an effective integrated method for controlling soybean stink bugs, the biology, ecology and utilization of egg parasites introduced from Japan were studied, by comparing with those of the native ones. For rearing the egg parasites, Erlenmeyer flasks, each with a cotton stopper, containing honey diluted with water, were placed in growth chambers where the temperature and illumination were controlled. For producing egg masses of soybean stink bugs, several species of stink bugs were reared using a simple mass rearing method,[5] in which the insects were put in a plastic container with a diet consisting of a mixture of dried seeds of soybean, ground nuts and alfalfa, and water placed under a filter paper.

As a result, percentage parasitism and emergence of egg parasites which were indigenous to and introduced from Japan were made clear as shown in Fig. 2. Based on the experiment, the order of the efficacy of the egg parasites in parasitism and adult emergence was considered as follows: *Trissolcus basalis* ⩾ *Telenomus mormideae* ⩾ *Trissolcus mitsukurii* ⩾ *Ooencyrtus nezarae* ≫ *Telenomus chloropus* ≫ *Tel. gifuensis* ≫ *Trissolcus* sp.

From the developmental periods of the major four species of egg parasites, *Trissolcus basalis, Trissolcus mitsukurii, Telenomus mormideae* and *Ooencyrtus nezarae* at 20, 22, 24, 26 and 28 °C, the effective accumulated temperatures and the developmental zero points of them were made clear as shown in Table 1.

Longevities of the adults of the major four species of egg parasites described above were made clear. As an example, the mean longevity of *Trissolcus mitsukurii* was about 2 months, 23 days, and 10 days at 20, 24, and 28 °C, respectively. Also, the maximum longevity of the same species without food and water was about 8, 5, 4, and 2 months, at 20, 22, 24, and

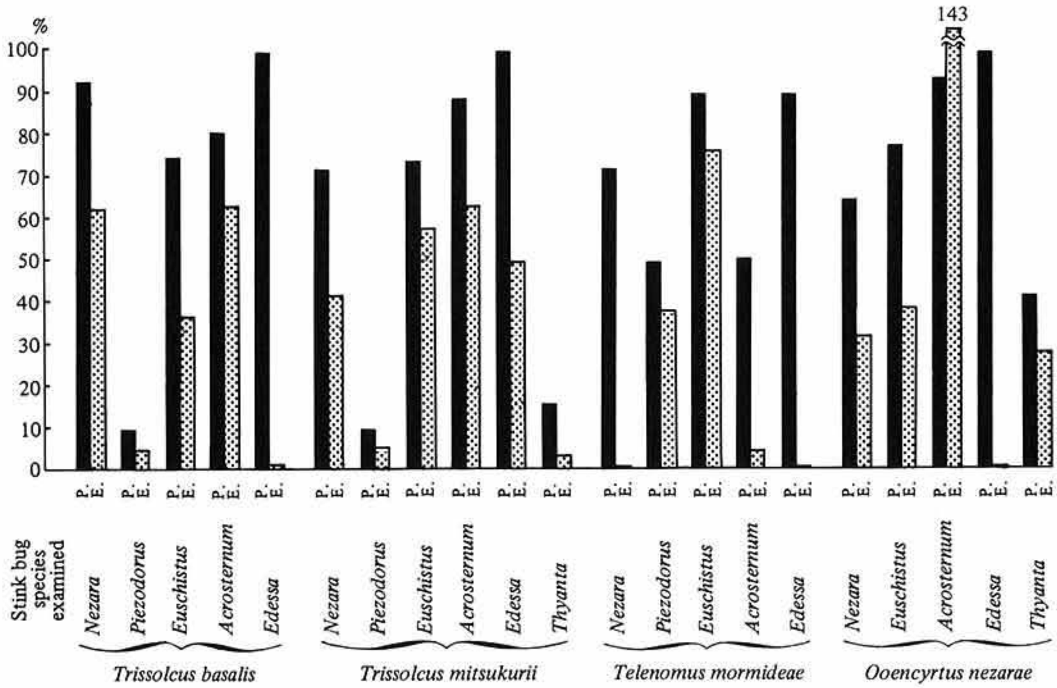

Fig. 2. Percentages of parasitism and adult emergence of egg parasites at the temperature from 20 to 28°C

P.: Parasitism
E.: Emergence

Table 1. Effective accumulated temperature and developmental zero point of eggs and larvae of four species of egg parasites of stink bugs

Species	Effective accumulated temperature (°C)			Developmental zero point (°C)		
	♀	♂	♀·♂	♀	♂	♀·♂
Trissolcus mitsukurii	165.77	145.90	149.37	11.51	12.15	12.29
Trissolcus basalis	176.62	146.97	170.11	11.70	12.61	11.77
Telenomus mormideae	185.83	179.22	183.27	11.41	11.20	11.41
Ooencyrtus nezarae	238.38	224.08	234.43	9.23	9.57	9.34

26°C, respectively.

Trissolcus mitsukurii does not enter the diapause under the usual conditions of the Cerrados, because it did not enter the diapause even when the illumination period was 11 hr at 20°C or 13 hr at 22°C. The adult was able to multiply throughout the year, provided the stink bug eggs were present. This species was able to parasitize the eggs of all of major Pentatomid species of soybean throughout a year, and also to survive for a long period of time under winter (dry season) condition, so that the species is considered to be able to adapt itself to the environment of the Cerrados.

Females of *Trissolcus basalis* and *Ooencyrtus nezarae* usually do not compete with females of the same and other species for oviposition. However, the females of *Trissolcus mitsukurii* showed a competitive behavior, and this species was more dominant than any of the other species mentioned above.

In an experiment in which about 100 females of *Trissolcus mitsukurii* were released at the center of a green house, the percentage parasitism in *Nezara viridula* eggs was 40.3, 3.6, 3.4, and 1.4%, respectively, at a distance of 0, 2, 4, and 6 m from the release point.

In an experiment in which more than 1,000 females of *Trissolcus mitsukurii* were released in a soybean field, the percentage parasitism in soybean stink bugs, mainly *Nezara, Piezodorus, Euschistus* and *Acrosternum,* was about 50% in the area where the egg parasites were released. Three days and two weeks after the release, the parasitism was recognized in an area 20 m apart and an area 100 m apart from the site of release, respectively.

Furthermore, the result of a wide area experiment in which a large number of *T. mitsukurii* were released, in addition to existing native natural enemies, to the whole field area of CPAC indicated that the percentage parasitism by these egg parasites of soybean stink bugs increased by about 20%, and the percentage parasitism reached as high as about 70 (Fig. 3). The percentage of hatching of

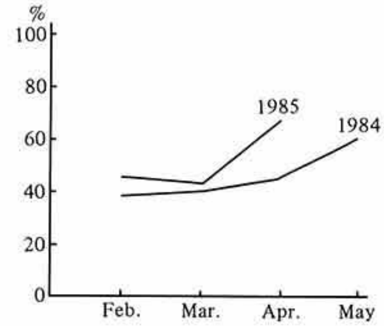

Fig. 3. Monthly prevalence of percentage parasitism of egg parasites including *T. mitsukurii* in Pentatomid eggs in soybean fields of CPAC

the soybean stink bugs which decreased by about 30%, reached approximately 20% in April of 1985, compared with the previous year. These changes may be caused by the release of more than 9,000 females and 7,000 males of *Trissolcus mitsukurii*, in the course of the field experiments conducted from February, 1984. The percentage parasitism by egg parasites of stink bugs in CPAC and PAD-DF, was lowest at the end of the dry season, September or October in general, and it gradually increased during the rainy season, being highest in May, the beginning of the dry season.

The use of *Trissolcus mitsukurii* and *Ooencyrtus nezarae* is considered very promising, in addition to the role played by the native egg parasites, such as *Trissolcus basalis* and *Telenomus mormideae*, for

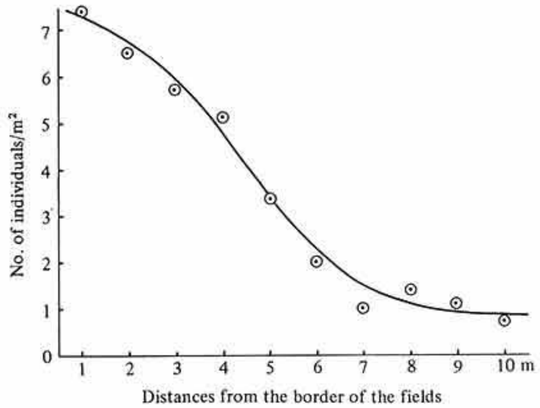

Fig. 4. Population density of stink bugs in soybean fields

controlling the population of soybean stink bugs in the Cerrados.

Cultural methods for controlling soybean stink bugs, using early maturing varieties and trap crops

To establish an effective integrated cultural method for controlling soybean stink bugs, we studied the utilization of early maturing varieties so as to avoid the damage due to stink bugs, along with a method to attract soybean stink bugs by trap crops and to control them effectively by minimum

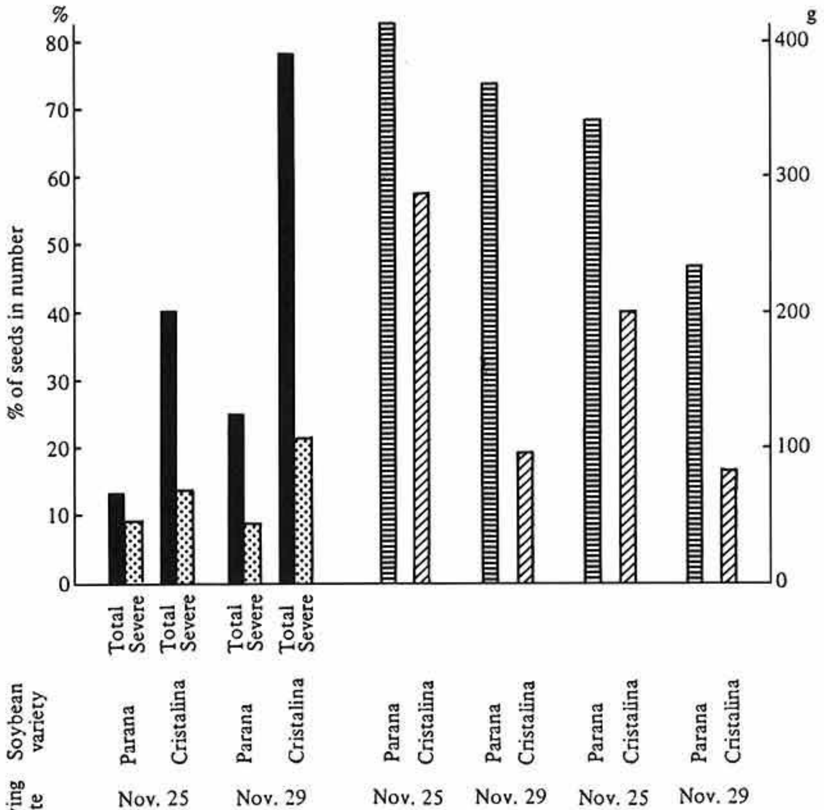

Fig. 5. Difference in the percentages of soybean seeds damaged by stink bugs between the early maturing variety Parana and the late maturing variety Cristalina

insecticide application.

According to a basic study on the life history of soybean stink bugs in the natural environment of the Cerrados and crop fields, *Nezara viridula, Piezodorus guildinii* and other soybean stink bugs were hardly able to multiply on the wild plants in the Cerrados. However, they rapidly multiplied on such cultivated crops as wheat, pea, kidney bean, soybean, especially on soybean through three or four generations in a year. Also, in the investigation of the horizontal distribution of soybean stink bugs in several soybean fields, the population density of soybean stink bugs was recognized to be conspicuously higher in the marginal areas of the soybean fields, particularly in the areas within 5 m from the border (Fig. 4).

As the stink bug population is still sparse in January, early maturing varieties such as Parana, sown at the usual time, can escape from the damage as shown in Fig. 5. However, when the population density of stink bugs with a size of more than 5 mm is higher in the marginal area than the economic injury threshold, insecticides should be applied only to the marginal areas. This treatment is enough to keep the stink bug population at a low level in the whole field.

On the other hand, since the stink bug population becomes denser after February, the late maturing varieties such as Cristalina are severely damaged in general, as shown in Fig. 5. Therefore, a field experiment to establish "the trap crop method", was designed using two characteristics of the field behavior of soybean stink bugs, that is their population densities are dense in the marginal areas of soybean fields, and their adults are conspicuously attracted by the early to the middle seed-thickening

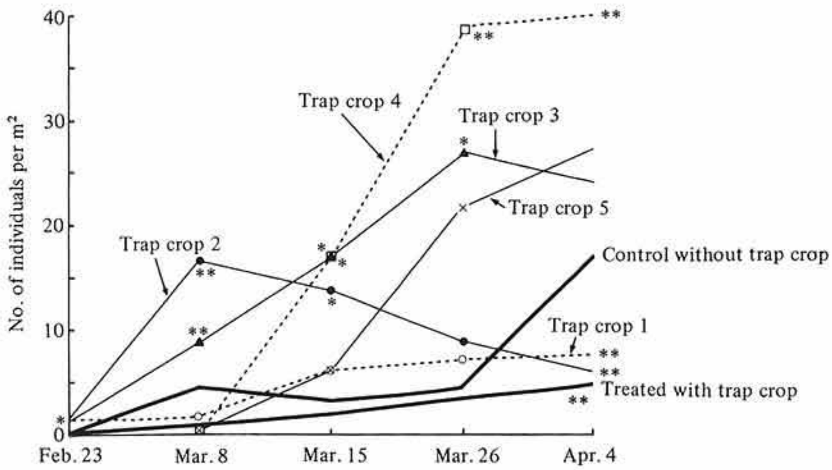

Fig. 6. Effect of the trap crop method on the population of soybean stink bugs
The number of soybean stink bugs, including eggs, was counted on trap crops planted on the margin of the soybean field (var. Cristalina), and on the soybean field with the trap crops (Treated) and without trap crops (Control). The counting was made just before insecticide application. The experiment with 3 replications.

Soybean field	Sowing date	Trap crop	Sowing date
Treated:	Nov. 25	1. Cristalina	Nov. 20
Control:	Nov. 25	2. UFV-1	Nov. 25
		3. Cristalina	Nov. 25
		4. Doko	Nov. 25
		5. Cristalina	Dec. 3

*,** Significant differences between the control and others at 5% and 1% level.

Table 2. Percentages of soybean seeds damaged and not damaged in the experiment on "the trap crop method" in Cristalina field in 1983—'84

Treatment		Percentage in number of seeds			
		Damaged by stink bugs			Not damaged
		Severe	Light	Total	
Trap variety	No. 1	5.8	18.4	24.2*	72.6*
	No. 2	4.6**	14.2*	18.8**	78.8**
	No. 3	7.1*	27.9	35.0	61.4
	No. 4	7.7*	28.6	36.3	58.4
	No. 5	10.2	51.4**	61.6**	34.5**
Cristalina with trap varieties		7.8**	21.1	28.9*	66.4*
Cristalina without trap varieties (control)		13.9	26.5	40.4	57.0

*, **: Significant differences between a control plot and other plots at 0.05 and 0.01 level, respectively.
Trap varieties (see Fig. 6): One row for each variety, arranged in order of 1 to 5 from the field border. By such an arrangement, successive flowering at interval of 1 week or so could be obtained.

Table 3. Field design of "the trap crop method" for controlling soybean stink bugs in the Cristalina field

Trap variety	Expected		Schedule of insecticide application				
	Flowering date	Ripening date	1st	2nd	3rd	4th	5th
1. Santa Rosa	Dec. 8	Mar. 2	Dec. 29	Jan. 8	Jan. 18	—	—
2. UFV-1	Dec. 19	Mar. 7	—	Jan. 8	Jan. 18	Jan. 28	Feb. 7
3. Cristalina	Jan. 2	Mar. 13	—	—	Jan. 18	Jan. 28	Feb. 7
4. Doko	Jan. 9	Mar. 24	—	—	—	Jan. 28	Feb. 7
5. Tropical	Jan. 11	Mar. 30	—	—	—	Jan. 28	Feb. 7

Trap varieties are planted just after the planting of Cristalina for production. Expected date of germination: Nov. 3. Period during which stink bugs are strongly attracted: 2—5 weeks after flowering, Dec. 22—Feb. 15 (for about 8 weeks).

stages of soybean,[2] and deposit their eggs to multiply their offsprings.

In the experiment, three trap varieties of soybean were planted in the marginal areas, occupying about 5% of the whole area of Cristalina field. Only the trap varieties were treated with an insecticide, Sumithion, five times from three weeks after the flowering time, at intervals of ten days.

In the experiment, a large number of stink bugs were attracted by the trap varieties, and were controlled effectively by insecticide applications, as shown in Fig. 6. As a result, the percentage of Cristalina seeds damaged by stink bugs was significantly decreased, namely the percentage of the seeds not damaged was significantly increased as shown in Table 2.

A practical field design of the trap method, tentatively recommend to farmers, is shown in Table 3.

Conclusion

On the basis of these results, it is concluded that the trap crop method, combined with insecticide application only to the trap crop, is a highly effective and rational component of the integrated control of soybean stink bugs. As the biological control by the use of natural enemies is another important component, it must be emphasized that the trap crop method does not reduce the population of natural enemies, because stink bugs attracted by the trap crop growing at the margin of the field are killed by the minimized amount of insecticides, without giving adverse effect on the natural enemies in the most area of the soybean field.

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