EFFECT OF INSECTICIDES ON PREDATORS AND PARASITOIDS OF SOYBEAN PESTS

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ABSTRACT - To evaluate the effect of chemical and biological insecticides on predators and parasitoids of soybean pests, an experiment with randomized block design, with plots measuring 100 x 100 m replicated three times, was set up. The treatments were applied two times on each plot, the first for controlling the velvetbean caterpillar (*Anticarsia gemmatalis*), and the second for stink bugs (*Nezara viridula, Piezodorus guildinii* and *Euschistus heros*) control. The treatments consisted of the insecticides and doses (g a.i./ha) applied two times: 1. endosulfan (210/525); 2. lambda-cyhalothrin; (4.5/9); 3. monocrotophos (96/180); 4. *Baculovirus anticarsia* (24 g formulated)/monocrotophos (120) + NaCl (0.5%). The shock method was used to sample the arthropod population, by applying a broad spectrum insecticide (dichlorvos) over the sampling area, collecting the dead insects on plastics placed on the ground and transferring them to the laboratory to be identified and counted. All insecticide treatments reduced the number of predators two days after being applied to control stink bugs, but only lambda-cyhalothrin showed a lower population than the check, 26 days after the first application. The determination index of parasitoid versus total dipterans population was r^2=0.99, meaning that the insecticide effect over the total dipterans and the population of parasitoids of this orders was the same. The parasitoids populations and the index of parasitism of pests were not affected by the treatments.

Key words: *Glycine max*, velvetbean caterpillar, stink bugs.

EFEITO DE INSETICIDAS SOBRE PREDADORES E PARASITÓIDES DE PRAGAS DE SOJA

RESUMO - Um experimento foi instalado para avaliar o efeito de alguns inseticidas químicos e biológicos sobre predadores e parasitóides de pragas de soja, utilizando-se o delineamento de blocos ao acaso com três repetições, e parcelas medindo 100 m x 100 m. Os tratamentos consistiram em duas aplicações de inseticida, sendo a primeira para controle da lagarta da soja (*Anticarsia gemmatalis*) e a segunda para o controle de percevejos (*Nezara viridula, Piezodorus guildinii e Euschistus heros*). Os inseticidas e doses (g i.a./ha) utilizados (1ª. e 2ª. aplicação) foram: 1. endossulfan (210/525); 2. lambda-cialotrina (4,5/9); 3. monocrotofós (96/180); *Baculovirus anticarsia* (24g formulado)/ monocrotofós (120) + NaCl (0,5%). O método do choque foi utilizado para amostrar a população de artrópodos, aplicando-se um inseticida de largo espectro (diclorvos) sobre a área a amostrar, coletando os insetos mortos sobre um plástico, colocado entre as linhas de soja, e transportando os insetos para o laboratório, onde foi procedida a identificação dos mesmos. Todos os inseticidas reduziram o número de predadores, dois dias após a aplicação para controle de percevejos; porém, 26 dias após a primeira aplicação, apenas lambda-cialotrina reduziu a população de predadores, em relação à testemunha,. O índice de determinação dos dípteros parasitóides, contrastado com o total de dípteros, foi de $r^2 = 0.99$, significando que a variação dos grupos tem causa comum. As populações de parasitóides e os índices de parasitismo não foram afetados pelos tratamentos.

Palavras-chave: *Glycine max,* lagarta da soja, percevejo.

INTRODUCTION

Insecticides are powerful tools for regulating outbreaking pest populations, and are often the only available to growers when pests approach the economic damage level. The concept of Integrated Pest Management includes the harmonic use of pest control techniques, in order to avoid a negative effect of one over the other. In the case of using insecticides as a tactic for pest control, a consideration must be made about its selectivity to natural enemies. The key point is how to use pesticides so that their maximum benefits can be obtained and, at the same time, minimizing its non-

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target effects.

Selectivity has a relative sense, as all pesticides have a degree of selectivity. At one extreme, a chemical that sterilizes the area, where it has been applied, would be a true non-selective one, whereas a pesticide that only kills the target organism and nothing else would be completely selective. In this last case some insect viruses are the best known examples. Two types of selectivity should be considered: the intrinsic selectivity of the chemical and its selective use. Insecticides possessing inherent low toxicity to all non-target species are unusual. The selectivity concept should be expressed in relation to the arthropod community to whom differential impact is desired, as the insecticide effect can vary according to the beneficial organism (predator or parasitoid), or its feeding habit (chewing or sucking). In this context, the degree of intrinsic selectivity can be different among crops or regions, depending on the community composition. OLIVEIRA et al. (1988) produced a comprehensive study on the intrinsic selectivity of several insecticides on natural enemies of soybean pests in Brazil.

A recently developed group of insecticides, the non-steroidal ecdysteroid agonists could be an example of intrinsically low toxicity to beneficials. Insecticides of this group, like the tebufenozide, induce an anticipation of larval molt, by interfering directly with the ecdysteroid receptors, which is lethal to the insect (ALLER and RAMSAY, 1988; CHANDLER et al., 1992; SILHACEK et al., 1990; WING et al., 1988). No effects of tebufenozide on *Orius insidiosus* (SMAGGHE and DEGHEELE, 1994) or *Podisus nigrispinus* and *P. maculiventris* (SMAGGHE and DEGHEELE, 1995) were observed. Diflubenzuron is also largely considered as having a high degree of intrinsic selectivity, as its innocuity has been proved to predacious mites (HASSAN et al., 1987; RIEDL and SHEARER, 1988), Coccinelidae (WESTGARD et al., 1986), carabids (PASINI and FOERSTER, 1989), neuropterans (ABLES et al., 1977; FYE, 1985), hemipterans (CIGLAR and CVETVOKIC, 1989; HOYING and RIEDL, 1980), earwigs (DRUKKER and BLOM, 1985) or parasitoids like himenopterans (HOUSE et al., 1980; NAVARAJAN, 1988) or dipterous (HASSAN et al., 1987). Otherwise, some studies showed the effect of diflubenzuron on beneficials, like mortality or reproduction abnormalities in *Amblyseius gossipi* (EL-BANHAWY and REDA, 1988), *Chrysopa carnea* (HASSAN et al., 1987; ZAKI and GESRAHA, 1987), *Deraecoris brevis* and *Anthocoris nemoralis* (BURTS, 1983), and *Cirrospilus vitratus* (MEY, 1988). Sub-lethal effects, like morphological abnormalities, body weight and mobility reduction, were also observed as side effects of diflubenzuron on *Forficula auricularia* by SAUPHANOR et al. (1993).

The selective use of insecticides can be achieved by reducing the number of applications or field rates, timing applications as to desynchronize with beneficials peak populations or most affected instars, and leaving refugia for predators and parasitoids in the field. Alternating insecticide application on apple orchards, so even rows were sprayed seven days after odd rows, improved the insecticide selectivity according to ASQUITH (1973). CROFT and BROWN (1975) observed that even insecticides with low degree of selectivity to a predacious mite (*Amblyseius fallacis*) could be used in a selective way during the spring, when the mites were in the soil. CORSO and GAZZONI (1995) failed to demonstrate refugia importance to selectivity, as none of the insecticides studied reduced the beneficials population, in order to allow refugia to be an important selectivity factor.

The main objectives of this study were to determine the seasonal-long impact of insecticides on predators and parasitoids of soybean pests and on the parasitism index; to observe the occurrence of secondary pest outbreak and pest population resurgence; and to determine possible differences between the effect of insecticides on Diptera in general, as compared to parasitoid population of species of this order.

MATERIAL AND METHODS

The experiment was carried out at Tibagi farm, (Sertanópolis, Paraná). Soybean cv. BR-37 was planted in Nov. 24, 1993, with rows spaced by 0.38cm, and 20 plants per meter. The experimental design used was a randomized block with three replications, and plots measuring 100 m x 100 m. Treatments used are presented in Table 1.

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Table 1. Insecticides and doses used to verify its selectivity to beneficial arthropods

Velvetbean caterpillar (VBC)		Stink bugs (SB)	
Insecticide	**Dose (g a.i./ha)**	**Insecticide**	**Dose (g a.i./ha)**
Endosulfan	210	Endosulfan	525
Lambda-cyhalothrin	4.5l	Lambda-cyhalothrin	9
Monocrotophos	96	Monocrotophos	180
Baculovirus anticarsia	20*	Monocrotophos + salt**	120
Control (prophenophos)	40	Control	

* 20 g commercial formulation/ha.
** NaCl at 0.5% in insecticide solution

Insecticides and doses were selected among the most commonly used by soybean growers (GAZZONI, 1994). Addition of salt (NaCl) to the insecticide solution in the sprayer tank is a technology developed by CORSO (1988), which resulted in a reduction of ca. 50% in the insecticide field application dose without reducing the target pest mortality. The insecticide prophenophos, known for its low impact upon soybean pest predators (OLIVEIRA et al., 1988), was applied on the control plots at 40% of the recommended dose, to partially control the population of the velvetbean caterpillar (*Anticarsia gemmatalis*), avoiding possible large defoliation and consequent disturbance of pest and natural enemies distribution in the field by shortage of food. A tractor-propelled sprayer, delivering 180 l/ha, applied the insecticides. Applications were made on January 5, for the control of the velvetbean caterpillar, and on February 21, for control of the stink bug complex (mainly *Nezara viridula, Piezodorus guildinii* and *Euschistus heros*), which are the key pests to soybeans in Brazil.

Both, pests and natural enemies, were sampled each week, from January 4 up to the soybean harvesting (March 24). In each plot, a permanent flag placed in the plots identified four sampling sites located at ca. 30 m of the nearest plot edges. Inside a circle of 10 m radius, centered on the flag, 4 m of soybean row were sampled each week. Samples were assigned to a cardinal point, rotating clockwise weekly, to avoid effect of one week sampling over the next one. The shock technique was used, consisting of spraying a broad spectrum insecticide (dichlorvos 500 g a. i./ha) over the soybean rows to be sampled, and collecting dead insects fallen on a cloth placed on the ground. Insects were transferred to the laboratory, to be identified and counted. All phytophagous and beneficial insects were identified to the lowest possible taxonomic level, but specifically parasitoids were identified to species or genus level, to compare the effect of treatments on beneficial and other species of Diptera and Hymenoptera.

The mortality factors of both, *A. gemmatalis* larvae and stink bug eggs, were recorded in the laboratory. Ten VBC larvae of 3rd. instar were collected from each plot, in three sampling dates between January 4 to 17. Larvae were placed in Petri dishes and fed on soybean leaves previously sterilized with a 5% NaClO water solution washing. The causes of mortality were established, and dead insects were discarded, as well as moths normally emerged. Egg parasitism index was established by collecting 10 egg masses of *N. viridula* from each plot, in each sampling date from March 3 to 24. When the egg masses of *N. viridula* did not reach the established number, egg masses of *P. guildinii* and *E. heros* were collected to complete the sample. Eggs were placed in Petri dishes containing sterilized soybean pods, and were observed until nymphal hatching or the emergence of parasitoids.

Data were submitted to ANOVA using the SANEST package (ZONTA et al., 1982), after being tested for its suitability to the requirements of the analysis of variance. When ANOVA showed a significant effect, means of treatments were compared using the Duncan's multiple range test at 5% of probability.

RESULTS AND DISCUSSION

Predators - Major species of predators found on the experiment were nabids, geocorids and *Orius* sp. (Hemiptera), *Callida* sp. (Coleoptera) and spiders, but data will be presented only for predators as a group, as the number of individuals of each species is usually low on each date, and also shows a high variability. For the most frequent predators found on the plots, the population of *Orius* sp. peaked in February 1 (data not shown), and almost disappeared from the field by the end of February, probably due to the lack of its preferred preys.

Almost the same seasonal trend was observed for *Tropiconabis* species, while the spiders distributed all over the season. The most likely explanation for this behavior is linked to the preferred host, as the range of hosts for spiders includes more preys than the other predators; nevertheless, generally they are polyphagous. Considering predators as a group, significant differences were found between the control and lambda-cyhalothrin (Figure 1), for the evaluation made 26 days after controlling VBC, following a trend of lower predators number, after the insecticide application. The predators number recovery was observed only 41 days after application, when this treatment showed the highest number, but not significantly different from the other treatments. These results were similar to those obtained by WHITE et al. (1992), where effects of this insecticide on natural enemies lasted 24 days, and there was a populational recovery to control plot levels at the time of subsequent infestations of *A. gemmatalis*, thus preventing the reaching of economic damage levels.

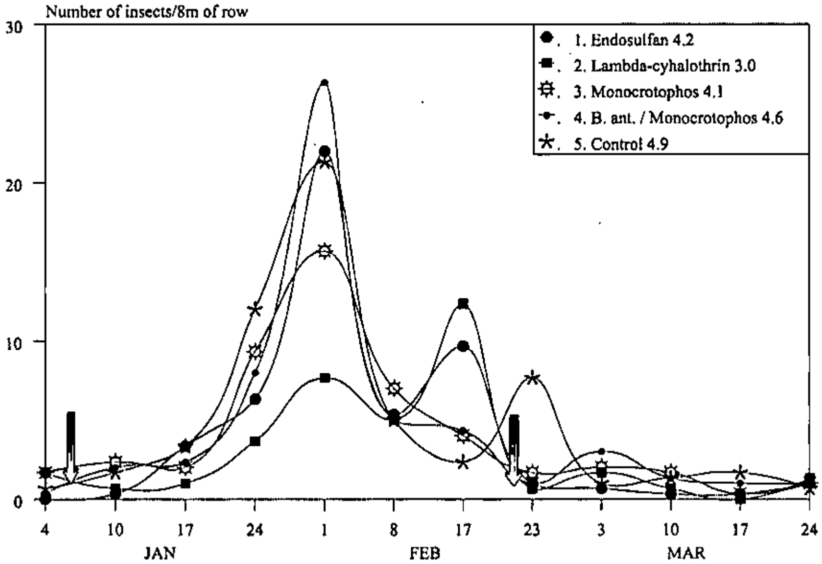

FIG. 1. Effect of experimental treatments on the total population of predators, on the specified dates.

A significant difference was also observed among the control and all insecticides, three days after application for the control of stink bugs. In this case, the most probable explanation for the difference on the second application, and not on the first, is due to the doses of the insecticides, which are at least the double for controlling stink bugs, when compared to velvetbean caterpillar. Also, the application of the innocuous *B. anticarsia* was replaced by monocrotophos + NaCl, less selective than the biological insecticide.

The seasonal accumulated number of predators was significantly lower for plots receiving lambda-cyhalothrin, when compared to the control. The same results were observed by WHITE et al. (1992), who indicated lack of selectivity of lambda-cyhalothrin to *Nabis capsiformis*. These authors did not accumulate the individual sampling values to make it possible to compare with present data; nevertheless evidences are that a lower number during 24 days would lead to seasonal-long lower number of predators.

At the predators peak, plots receiving monocrotophos presented 70% of the control numbers, but this difference was not significant, as the predators total number was so low that variation prevented observed differences to be significant. This difference was particularly due to reductions on the number of individuals of *Orius* and *Tropiconabis* (data not shown). HEINRICHS et al. (1979) stated that geocorids and nabids species were severely affected by monocrotophos at 250 g a.i./ha, resulting in significant differences compared to the control. In the present experiment lower doses of the insecticide were used, which explains a lesser impact of this insecticide on the predators. This kind of result can be an evidence of selective use of a non-selective insecticide, by reducing its field application dose to a minimum, in order to have sufficient pest control and reduced non-target effects.

The number of predators on plots treated with endosulfan was similar to the control plots. Endosulfan is known as a potent acaricide and had an impact on arachnid species. On a lesser extent, lambda-cyhalothrin and monocrotophos also reduced spiders number on the plots after the second application, notwithstanding significantly different from other treatments (data not shown). Monocrotophos partially affected the spiders population on the work of SONTAKKE (1993), even though phosphorinated insecticides are considered very toxic to arachnid species, as observed by SHUNMUGAVELU and PALANICHAMY (1991), PATEL et al. (1986), PATEL and NIGAM (1989) and BARATHI et al. (1982). The particular impact on spiders was not consistently observed on the overall predators (Figure 1), as arachnid constituted a minor fraction of the predators.

Parasitoids - Several species of parasitoids were identified, whereas *Trissolcus basalis, Telenomus* spp. (Hymenoptera), *Patelloa similis*, and *Eutrichopodopsis nitens* were the most commonly found ones. Species of Diptera were largely dominant over Hymenoptera, for parasitoid or non-parasitoid species. Comparing dipterans as a whole (Figure 2) with dipterans parasitoids (Figure 3), evidences are that parasitoids were higher at the end of January, while non-parasitoid species were dominant during the rest of the soybean season. No statistical differences were observed between treatments for each parasitoid species, for the group of parasitoids and even for Diptera species (Figure 2 and 3) or Hymenoptera (Figure 4), as well as for the sum of specimens of both orders.

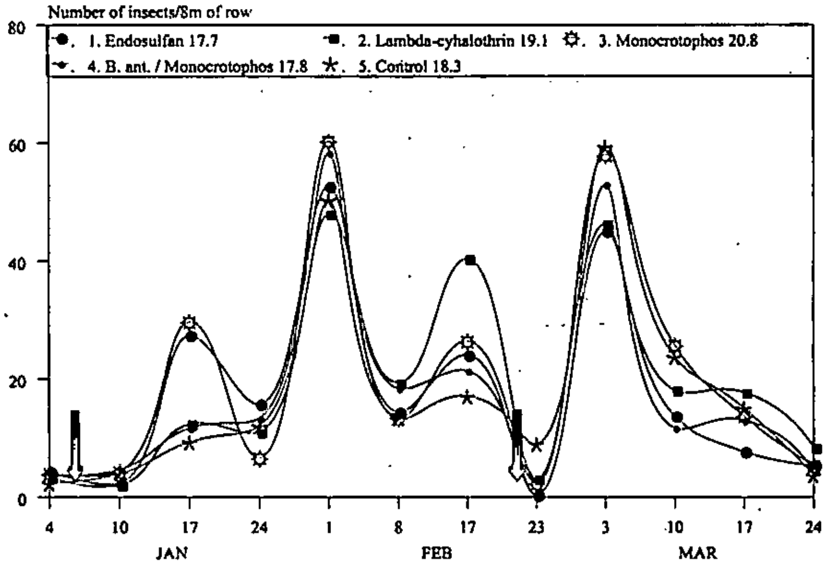

FIG 2. Effect of experimental treatments on the population of specimens of the order Diptera, on the specified dates

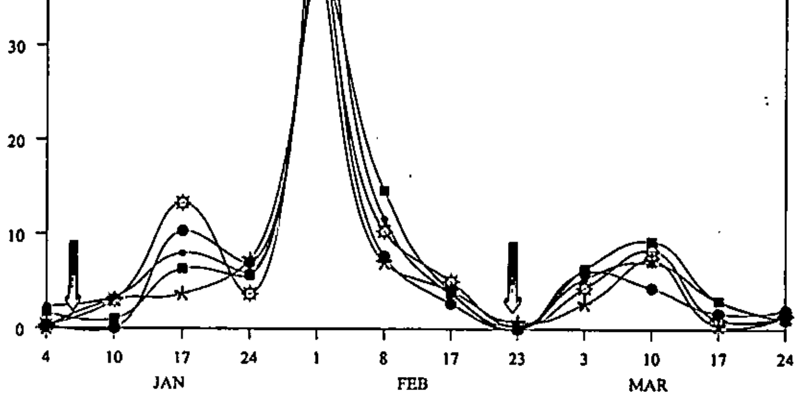

FIG.3. Effect of experimental treatments on the population of specimens of parasitoids of the order Diptera, on the specified dates.

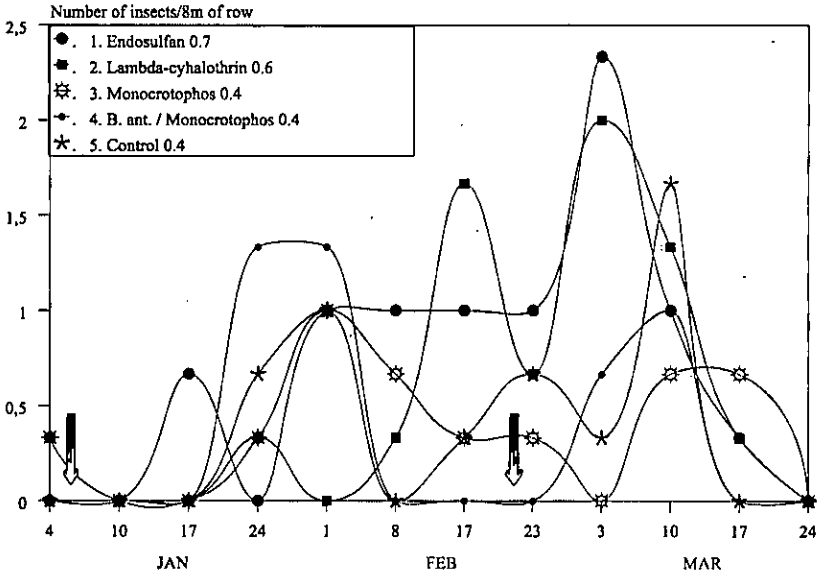

FIG. 4. Effect of experimental treatments on the population of specimens of the order Hymenoptera, on the specified dates.

The identification of each Hymenoptera or Diptera species when dealing with large number of samples, containing several species of different families, and also a large number of small size specimens is a time-consuming task, with field samples taking several days instead of minutes to be completely evaluated. Also it demands large evaluation teams, the support of taxonomists, normally requiring sending insects to specialists to identify to species level. This careful and complete procedure takes a lot of time, personnel and turns investigation budgets too expensive, often being impeditive to evaluate the impact of insecticides over the community of beneficial insects. In this study, it was correlated the impact of the treatments over two distinct groups of Diptera species: group one, consisting of exclusive identified parasitoid species; and group two, comprising all species of insects of these orders. Adjustment of seasonal populations of the two groups best fitted to a quadratic model ($Y = -2.9 + 0.3X + 0.0005X^2$), with a determination coefficient $r^2=0.99$, where the dependant variable is the parasitoid number. In spite of being significant, the quadratic component of the equation is very low, so the strongest relationship between the two insect groups is of a linear model. From this study is possible to infer that the source of variation of the number of both groups is the same, as demonstrated by the determination coefficient. In this sense, it is understood that, under the conditions of this experiment, it was possible to estimate the effect of insecticides over parasitic species of Diptera, by evaluating the impact of the chemicals upon the total number of individuals of this order.

Data on mortality of *A. gemmatalis* collected in the field and reared in the laboratory are presented on Figure 5. It was observed higher mortality caused by entomopathogens (especially *B. anticarsia* and *N. rileyi*) for those larvae collected on plots where chemical insecticides were applied. The possible explanation is that larvae were stressed by sub-lethal effects of insecticides, partially depressing their immunologic defense system, turning them more susceptible to disease infection. Plots receiving endosulfan presented the highest mortality caused by larval diseases (24%), but no parasitoid emergence was observed. It is supposed that parasitised larvae died first by disease infection, and in this case this insecticide would particularly favor insect diseases. Overall mortality caused by natural enemies (entomopathogens and parasitoids), on plots where chemical insecticides were applied, is the same (ca. 24%), reinforcing the conclusion of endosulfan favoring insect diseases incidence. Also the mortality on these treatments was higher than the observed for the control or plots receiving *B. anticarsia*, although no significant differences were found. Probably the most susceptible portion of the VBC population which received a *B. anticarsia* spraying died directly in the field, and larvae collected on these plots were just ones surviving the viral treatment, and might be slightly more tolerant to the virus, causing less viral mortality than plots receiving chemical insecticide.

Effects of treatments on stink bug eggs parasitoids are presented on Figure 6. The most frequent parasitoids found were *Trissolcus basalis* and *Telenomus* spp. The first species was dominant on *N. viridula* eggs, but species of *Telenomus* prevailed on *P. guildinii* and *E. heros* eggs. No significant differences were observed between the control and the insecticide treatments. The general trend was the decreasing of parasitism index for all treatments, including the control, towards the end of the season. Seasonal means indicated that plots receiving both lambda-cyhalothrin or *B. anticarsia* plus monocrotophos and salt showed the highest index of parasitism, while lower numbers of parasitised egg masses were associated with monocrotophos at full rate and the control, but none of these differences were significant.

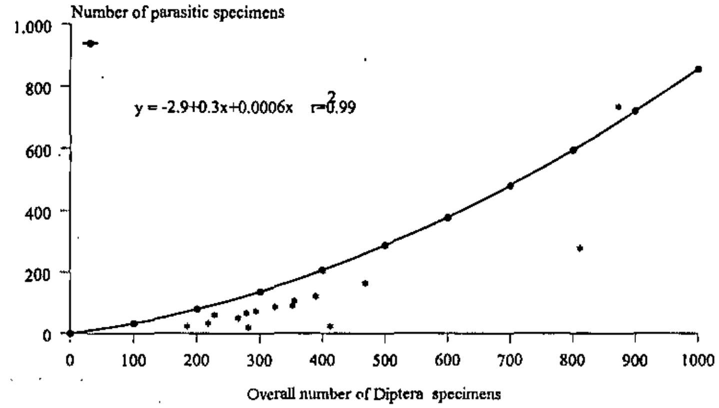

FIG. 5. Graphical correlation between parasitic and overall Diptera specimens, fitness equation and its coefficient of determination.

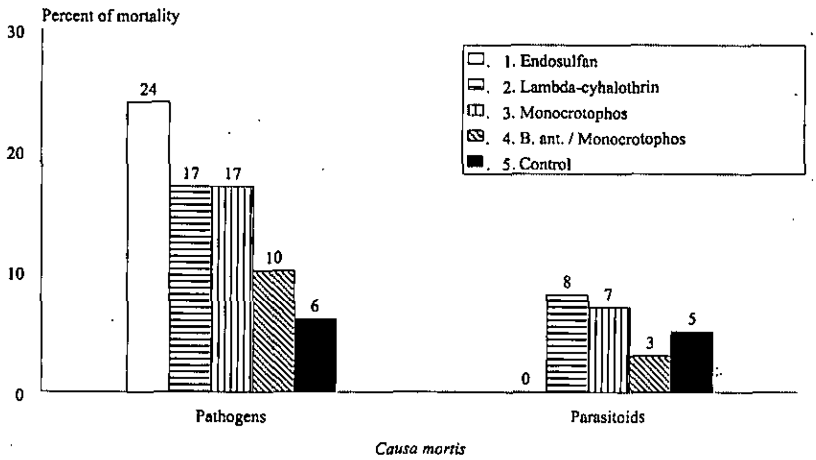

FIG. 6. Causa mortis and mean percent mortality of larvae of *Anticarsia gemmatalis* collected in the experimental plots and reared in the laboratory.

Pest resurgence and secondary pest outbreaks

The key pests like *A. gemmatalis* and the stink bug complex (mainly *N. viridula, P. guildinii* and *E. heros*) were followed throughout the season to observe possible population resurgence due to reduction of populations or activity of the natural enemies. Figure 7 shows the seasonal population of VBC, while stink bug complex is shown on Figure 8. No ressurgence of the stink bug complex was observed, as would happen if the insecticides had adversely affected the biological control agents population or activity. Population of VBC had a larger first peak on plots sprayed with *B. anticarsia*, due to the time required for contaminated larvae to die, generally seven days. As the sampling was made five days after application, and did not discriminate between healthy and diseased individuals, an erroneous impression of unsuccessful control may arise. Population of larvae on the control situated half-way between *B. anticarsia* and the other treatments, due to an application of prophenophos at 40% of the recommended rate. The application aimed to partially control the VBC population, avoiding large defoliation and consequent strong reduction of the VBC population. The lack of prey would possibly cause migration or death of natural enemies. In this case, an erroneous comparison would arise, as control plots could present a lower number of individuals of natural enemies, and might favor an insecticide with higher impact on the biological control agents.

Data on phytophagous coleopterans species (Figure 9) are shown, as representative of soybean secondary pests, being, normally, the most frequent on soybeans grown in the region where the experiment was carried out. Again, no deleterious effect of the treatments could be observed on both groups of insects, leading to the conclusion that the impact of treatments was not enough to induce pest population outbreaks.

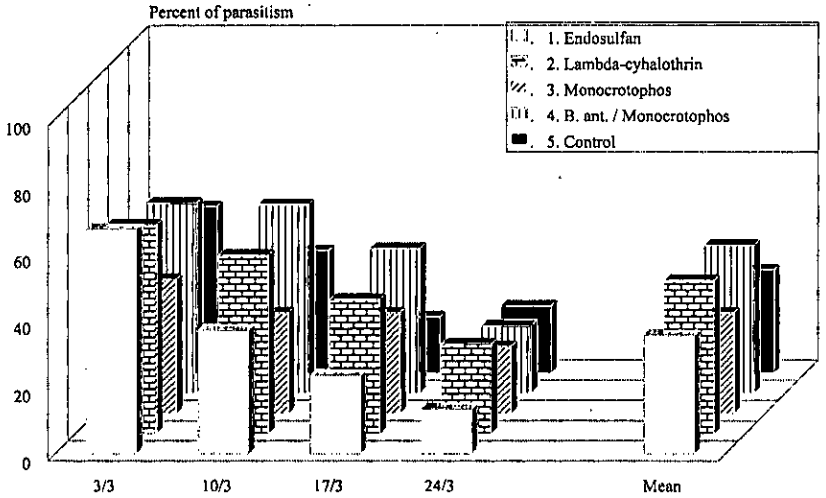

FIG. 7. Percent of parasitism of eggs of stinkbugs, collected on experimental plots and reared in the laboratory

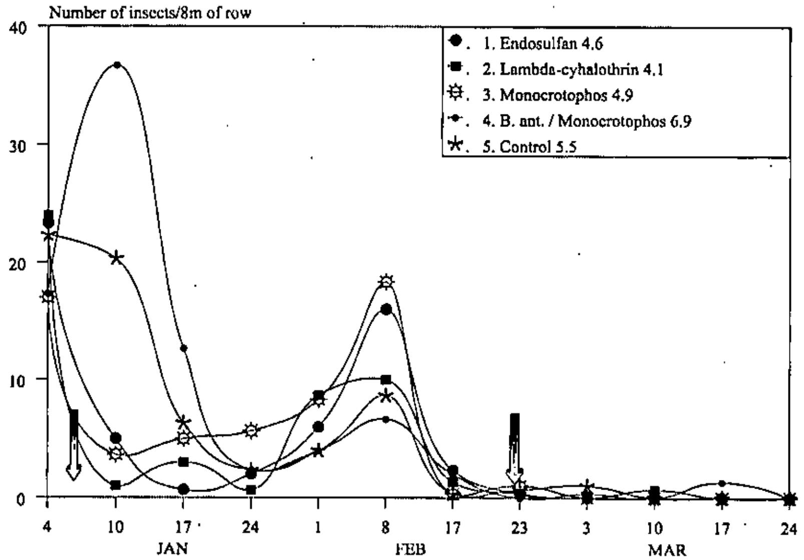

FIG. 8. Effect of experimental treatments on the population of Anticarsia gemmatalis, on the specified dates.

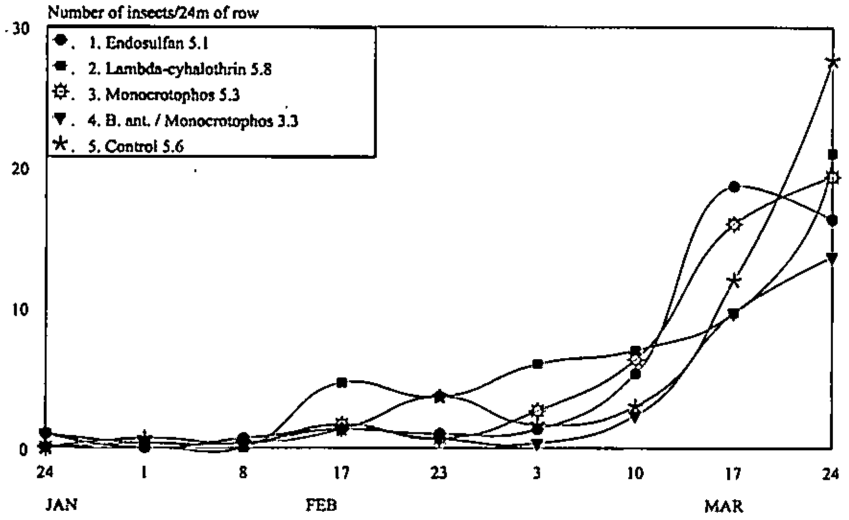

FIG. 9. Effect of experimental treatments on the population of stink bugs, on the specified dates.

CONCLUSIONS

Lambda-cyhalothrin at 4.5 or 9 g a.i./ha reduces the number of predators of soybean pests, while other tested insecticides only affect the predators number at the highest dose.

No effects of the tested insecticides are observed on the parasitoids number, or on the parasitism index.

No side effects, like pest resurgence or secondary pests outbreaks, are observed, due to the treatment application.

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