EMPRESA BRASILEIRA DE PESQUISA AGROPECUÁRIA - **EMBRAPA**

EMBRAPA AND BIOLOGICAL CONTROL

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ABSTRACT

This paper shows the contribution of EMBRAPA - Empresa Brasileira de Pesquisa Agropecuária - to biological pest control. Results from research carried out by EMBRAPA's units are presented. Several projects have been successfully concluded while others are still in various stages of development.

1. INTRODUCTION

The Brazilian Agricultural Research Corporation - EMBRAPA - forms part of the Ministry for Agriculture and Agrarian Reform and through forty-one research units is responsible for the coordination of the SCPA - The Cooperative Agricultural Research Network.

EMBRAPA carries out research activities in order to develop new technologies to improve farming at national level, to seek ever-increasing productivity, to conserve and to better environmental quality. One of the most important aspects of the farming yield process is the protection of plants and animals from the attacks of pests and the vectors of pathogenic agents, thus avoiding significant losses to yields and quality. EMBRAPA has played a significant role in developing research for the biological control of pests, here understood as those organisms that cause significant harm to crops, farm animals and to man himself.

Some of the main successful achievements in this field follow, together with problems faced and perspectives for the future.

2. WHAT BIOLOGICAL CONTROL IS

From an ecological point of view, biological control is the maintenance of the population of an organism through the action of natural enemies such as parasites, predators and pathogens

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at levels lower than those when they are not present. From an applied viewpoint, natural enemies are used to maintain the population of an organism below the level of economic harm. In medicine, biological control mainly refers to the use of entomopathogenic agents such as fungi, bacteria and viruses to combat insects, vectors of various diseases such as malaria and leishmaniasis. The common housefly, responsible for several problems in public health, has been controlled biologically with wasp parasites (see Berti Filho, 1986). In the applied approach, biological pest control is carried out in three different stages. Classical biological control consists in seeking, importing and colonizing natural enemies and frequently refers to pests previously introduced from other countries or regions. Conservation refers to the manipulation of the environments in such a way as to favor the development of activities of native natural enemies or those previously imported and established. Increase is due to the growing incidence of natural enemies with mass breeding generally effected in laboratories and later freed, innoculated or flooded into fields at strategic intervals when pest cycles occur (DeBach, 1964).

Major emphasis on the biological control of arthropods, pathogens and weeds results in the less intensive use of chemicals due to the application of insecticides, fungicides and pesticides thus reducing the risks of toxic wastes in the soil, water and produce consumed by the population.

3. ECONOMIC AND SOCIAL IMPORTANCE

Growing public demand for environmental protection has stimulated the development of biological pest control programs. Rising costs of farm chemicals have also urged the adoption of alternative methods for pest control.

All over the world, more than one hundred and twenty species of insects and mites have been partially or totally controlled after the introduction of natural control agents. This certainly means a significant decrease in the demand for chemicals that are potentially pollutent while at the same time keeping high farming productivity and protecting human health.

In Brazil, the first classic project for biological control introduced the microhymenoptera *Prospaltella berlesi* to control the white peach scale *Pseudoaulacapis pentagona* in 1921. There then followed a series of introductions of natural enemies to control the woolly apple aphid (1923), coffee fruit beetle (1929), sugarcane borer (1949), Rhodesgrass mealybug (1967) and wheat aphids (1979) (Robbs, 1992). However, the first biological projects for the control of the sugarcane borer (*Diatraea saccharalis*) and the sugarcane spittlebug (*Mahanawa posticata*) were carried out extensively, involving a significant number of specialists and with undoubted success and international repercussion (Botelho, 1990 & Alves, 1986). Nowadays, areas of approximately two million, one hundred and fifty hectares have benefitted from these projects.

In spite of the fact that these benefits have been accepted as the results of different projects for classical biological control, few have been submitted to an adequate quantification of the resulting economic benefits (Moscardi, 1990a).

More detailed studies are necessary in this sense to prove the real value of this method for control which although not duly quantified, has shown uncontestable advantages.

4. EMBRAPA's CONTRIBUTION TO BIOLOGICAL CONTROL SPECIALITY

Classical biological control projects in Brazil were limited in scope, until recently, due to the virtual inexistence of a quarantine system which is indispensible when natural enemies are introduced. Today, one of EMBRAPA's contributions to the area of biological control is the quarantine service for arthropods. It aims at reducing the probability of the introduction of undesirable organisms into Brazil because even inadvertedly they may be associated with those beneficial ones introduced. The quarantine laboratory for organisms useful for biological pest control at EMBRAPA's CNPDA - National Center for the Defense of Agriculture, Jaguariuna, São Paulo was accredited by the Ministry for Agriculture and Agrarian Reform on the fourteenth of November, 1991.

It is the duty of the technical staff linked to the quarantine service consisting of a consultative committee of three researchers or professors of recognized capacity in the field of biological control to analyze and emit considered opinions as to the convenience of liberating the natural enemies requested by the national research centers. These considered opinions help the Ministry for Agriculture and Agrarian Reform to take decisions on request. This activity was formerly performed by EMBRAPA's CENARGEN - National Center for Research of Genetic Resources and Biotechnology.

Some of the other main aims of this laboratory are to foster research in the area of classical biological control of pests, pathogens and weeds and carry out, under laboratory conditions, quarantine of introduced organisms. The laboratory also maintains up-to-date registers of all introductions of natural enemies in Brazil.

Today, the quarantine laboratory functions in temporary installations. However, awaiting favorable financial conditions, new and definite installations will be built with approximately seven hundred square meters. These installations will attend to all international norms which demand security for this type of laboratory.

Besides quarantine activities, EMBRAPA also carries out basic and applied research on biological pest control which involves not only classical biological control but also the conservation and increase of natural enemies.

Some important projects now follow:

AGRICULTURE

Some projects developed by EMBRAPA have resulted in practical applications and are in current use in Brazil. A successful example of the control of insects and pests is the program for the control of the wheat aphids (*Schizaphis graminum*, *Metopoiophium dirhodum* and *Sitobion avenae*) using such parasites as *Aphelinus* and *Aphidius* and the predators *Hippodamia quinquesignata* and *Coccinella septempunctata* introduced by EMBRAPA´s National Wheat Research Center, Passo Fundo, Rio Grande do Sul. This program avoided the use of one million liters of insecticide in the State of Rio Grande do Sul in 1977 and of 1.6 million liters in the State of Paraná in 1989. This is an economy of more than fifteen million dollars (Gassen & Tambasco, 1983 and the GUIA RURAL EMBRAPA, 1991). This benefit has increased from year to year and represents a great economy for the farmer.

In the Brazilian Northeast, researchers from EMBRAPA´s CPATSA - National Resarch Center for the Semi-Arid have achieved highly promising results to control the pest known as the tomato pin worm (*Scrobipalpuia absoluta*) introducing the parasitoid *Trichogramma pretiosum* in the Valley do São Francisco. In this area, pests caused harm to approximately 140 thousand tons of tomatoes equivalent to 8 million dollars since 1982 (Haji et alii, 1991). These experiments carried out by EMBRAPA/CPATSA researchers have proven that the level of *T. pretiosum* parasitism has varied from 19.5 to 42.90% with less than one year after the introduction of the parasitoid. Losses due to this pest have been considerably reduced after the introduction of the parasitoid. (Figure 1)

The production and application of the entomopathogen *Baculovirus anticarsia* to control the velvetbean caterpillar *Anticarsia gemmatalis* is an outstanding example in the field of soybeans. This project has been developed by EMBRAPA/CNPSO - National Soybean Research Center, in Londrina, Paraná under the coordination of Dr. Flávio Moscardi. In the harvest of 1989/90 one million hectares were treated with this virus. After beginning this system in 1983 some five million hectares of soybeans were treated with this pathogen economizing some fifty million dollars. To treat one hectare of soybean, catterpillars that have been previously infected with the virus are crushed and diluted in water for direct pulverization in soybean fields. The mixture is applied on soybean leaves and the catterpillars die six to seven days later affected by the virus. At present, the virus is applied in the form of powder dissolved in water. This formula has recently been passed to four private firms by the National Center for Soybean Research (Moscardi, 1990b and GUIA RURAL EMBRAPA, 1991). (Figures 2 and 3)

Since 1985, a baculovirus called *Baculovirus erinnuis* has been used on cassava to control the *Erinnuis ello*. Initially developed by ex-EMPASC - State of Santa Catarina Agricultural Research Enterprise - nowadays EPAGRI this technique was later used in the Northeast of Brazil by EMBRAPA/CNPMF National Cassava and Fruit Research Center. According to Alba R. Farias, a biologist, the virus was used to control *E. ello* in 800 hectares of cassava in the State of Bahia from 1985 to 1986. The Agronomic Institute of Paraná - IAPAR, also developed the production of virus to combat the disease throughout the State of Paraná. Among other promising research projects in the field of biological control using entomopathogens, the use of a virus for the biological control of the fall armyworm *Spodoptera frugiperda* in corn developed by the National Corn and Sorghum Center - EMBRAPA/CNPMS should be mentioned (Valicente & Cruz, 1991).

Control of the rice bug *Tibraca limbativentris* using the fungus *Metarhizium anisopliae* has been studied by researchers from the National Lowlands Research Center (EMBRAPA/CPATB). This highly virulent fungus has reduced the rice bug population in up to 90% twenty days after application.

Two strains of fungus *Colletotrichum gloesporioides* were also isolated from the mealybug *Orthezia praelongain* citrus. According to the researchers from the National Center for the Defense of Agriculture (EMBRAPA/CNPDA) this fungus, pulverized in a concentration of 10^8 conid/ml, provokes an 80 to 100% mortality rate, thus maintaining the *O. praelonga* in equilibrium under field conditions (Robbs et alii, 1990). Fungi sprayed in orchards in the Baixada Fluminense, RJ have achieved excellent results in the control of this insect.

Biological control for soybeans has been highly successful when treating the stink bugs (*Nezara viridula, Piezodorus guildinii* and *Euschistus heros*) using the parasitoid eggs of the *Trissolcus basalis*. Using the breeding process developed by the National Soybean Research Center, EMBRAPA has produced and released 1.5 million small wasps each harvest. This has meant a significant reduction of the use of insecticides in the control of these pests (Correa-Ferreira, 1991).

Great advance has been made in biological control of the wood borer *Sirex noctilio* in the States of Rio Grande do Sul and Santa Catarina. This insect, which is very well-known in New Zealand and Australia, has only recently been introduced to Brazil. In 1989, this insect provoked the total loss of more than one million trees or 425 cubic meters of pinewood. Researchers from the National Forest Research Center (EMBRAPA/CNPF) adapted a technique for the use of nematodes (*Deladenus siricidicola*) in the combat of this insect with results that were sufficiently satisfactory (GUIA RURAL EMBRAPA, 1991). First released into fields in 1990, parasitism evidenced averages of 30% and reached a maximum of up to 75%. Mass breeding of this nematode is being developed for release in fields of the States of Santa Catarina and Rio Grande do Sul in 1992.

EMBRAPA researchers have co-participated in research activities with other national and international research institutes and organizations, thus promoting the use of arthropod biological control in other countries. One example cited is the project for cassava biological pest control developed together with International Tropical Agriculture Center - CIAT, Columbia and the International Institute of Tropical Agriculture - IITA, Nigeria. Thus, the cassava mealybug *Phenacoccus manihoti* is controlled in Tropical African countries by introducing natural enemies supplied by the State Research Center - UEPAE/Dourados, Mato Grosso do Sul. Nowadays, this is one of the main examples of classical biological control carried out and cited worldwide (Neuenschwander, 1990). In this same way, research conducted in the Northeast with the participation of CPATSA, CNPMF and CNPDA resulted in the detection of efficient predators of another great cassava pest - the green mite *Mononuchellus tanajoa*. Some of these predators were sent to African countries where they are now settled and have begun to present the first positive results. (Figure 4)

The biological control program for plant diseases is one of the main activity areas explored by EMBRAPA specialists. To control apple root rot caused by the fungus *Phytophthora spp.*, the antagonic fungus *Trichoderma viride* was isolated and used. This was developed by the National Research Center for Temperate Climate Fruit Crops (EMBRAPA/CNPF) (Sanhueza, 1990 and 1991). New biotypes of *Trichoderma harzianum* resistant to fungicides benomyl and iprodione were developed to allow joint use of this fungus with reduced dosages of these chemicals applied control to such root fungi as *Sclerotinia minor* and *S. sclerotiorum* in lettuce (Melo et alii, 1991 and Silva & Melo, 1990). This research has been carried out by the National Research Center for the Defense of Agriculture (EMBRAPA/CNPDA). Results are promising when used by small farmers. While still in the experimental phase and in controlled conditions, the biological control of the soft rot in potato tubers (*Erwinia carotovora*) has applied plant growth-promoting rhizobacteria (Mantovanello & Melo, 1990). (Figure 5)

The biological control of phytopathogenic nematodes can be carried out by different organisms, for example bacteria, viruses and other nematodes. Tests were run to select strains of fungi *Paecilomyces lilacinus* and *P. fumosoroseus* with potential for the colonization of immature eggs (immovable embryos) and mature ones (movable embryos) of the nematode *Meloidogyne javanica*. Some of the *Paecilomyces* strains should be put on market in 1992, biological control of nematodes for commercial use developed by researchers from the National Research Center for Temperate Climate Fruit Crops (EMBRAPA/CNPFT) (Carneiro & Gomes, 1992).

EMBRAPA has also developed biological weed control. EMBRAPA/CENARGEN/BIOTECHNOLOGY working on weed research discovered agents with potential for the control of different species. EMBRAPA/CNPSOYBEAN discovered and has developed the fungus *Helminthosporium sp* to control leafy spurge, *Euphorbia heterophylla*. This formula in powder can be diluted and offers control equal to or even superior to chemical weedkillers when applied to plants after these have emerged and is of considerable importance in soybean (Yorinori & Gazziero, 1990).

VETERINARY SCIENCE

One of the most promising programs refers to the biological control of the horn fly, *Hematobia irritans* using the brown dung beetle *Ontophagus gazella*. The natural enemy was introduced in the State of Mato Grosso do Sul from specimens received from the United States. Eating dung, this insect inhibits the multiplication of the horn fly and several other worms and parasites that irritate cattle. This technology has been passed on to cattle breeders by the National Beef Cattle Research Center (EMBRAPA/CNPGC) and by the São Paulo State Research Center (UEPAE/São Carlos/SP) (Honner & Gomes, 1990 and Bianchin et alii, 1992).

The biological control of the gastrointestinal nematode *Heamonchus contortus* which affects bovines and other ruminants by means of the toxins produced by the *Bacillus thuringiensis* and other natural products in test. This project is coordinated by the National Dairy Cattle Research Center (EMBRAPA/CNPGL) and also counts on researchers from the National Research Center for the Defense of Agriculture (EMBRAPA/CNPDA).

MEDICINE

The production and use of the commercial bioinsecticide *Bacillus thuringiensis* variety *israeliensis* for the biological control of mosquitos *Aedes* and black flies is widely employed around the world. Researchers at the National Center for Genetic Resources and Biotechnology (EMBRAPA/CENARGEN/BIOTECHNOLOGY) research products on the base of *Bacillus sphaericus* which have proved efficient in the control of the southern house mosquito *Culex quinquefasciatus* and *Anopheles*. *Culex* control by *B. sphaericus* has proven that it is possible to substitute totally, chemicals for bioinsecticides, maintaining control and reducing costs. Studies on the use of various by-products and agroindustrial residues for *B. sphaericus* production are in the final stages. Contacts are being made with interested industries with a view to producing a new bioinsecticide on a commercial scale (Dias et alii, 1990 and Schenkel et alii, 1990). (Figura 6)

5. CONCLUSIONS

Many other research activities involving the use of natural enemies are being conducted by EMBRAPA and these projects are at different stages of development. Several should prove important and bring considerable advantages to the farmer and the consumer public in general.

Certainly, a laboratory with the specific aim to attend to national needs related to the quarantine of natural enemies recently accredited should facilitate and stimulate even more this type of study and, at the same time, promote the necessary safety to introduce exogenous organisms.

On the other hand, growing public awareness of the need to value and care for environmental quality, and increasing interest and consequent implantation of obligatory use of the farming prescription - authorization to purchase and compound chemical formulae - imply a growing demand for suitably trained specialists and laboratories appropriately equipped to attend to these concerns. Thus, as in other specialities, biological control strives to adopt and adapt scientific and technological knowledge from other areas of science. Thus, EMBRAPA/CENARGEN/BIOTECHNOLOGY has set up a well-installed structure and specialized staff in biotechnology, prepared to play important roles within the modern approach to biological control through the genetic manipulation of microbic agents. The integration of these specialists with others from EMBRAPA centers highlights Brazil´s role in biological control at international level. Different research has shown the potential that natural enemies have to control harmful pests. Research must continue to prove the socio-economical and ecological feasability of these alternatives. Not only must economic feasability of the alternative agents for control be shown but these same alternatives must also result in the conservation and improvement of enrivonmental quality. Thus, studies in biological control should englobe from basic studies of native fauna recognition to the eventual transfer of technology to the farmers, passing through the several stages from the introduction of efficient biological agents to mass production of the formulae to be applied in the field. In other words, biological control research projects should be carried out in a systematic way, given the necessary interaction between the different farming activities.

EMBRAPA, aware of its responsability at national level, and together with the universities and other research institutes, will strive to play its role and to contribute the greater production and healthier agriculture in Brazil.

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FIGURE LEGEND

FIGURE 1 - *Trichogramma pretiosum*, lepitopterous-pest egg parasitoid

FIGURE 2 - Soybean catterpillar infected with *Baculovirus anticarsia*

FIGURE 3 - *Baculovirus anticarsia* in dilutable powder form

FIGURE 4 - Cassava green mite predator found in the Northeast of Brazil

FIGURE 5 - Lab production of the fungus *Trichoderma harzianum* for the biological control of plant disease

FIGURE 6 - Bioinsecticide applications to control mosquito larvae in sewage