The insect **farmer**

Entomologist defends the use of biological control to combat crop pests

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SPECIALTY
Biological control of agricultural pests

EDUCATION
Undergraduate degree in agronomy (1968), master's (1972) and doctorate (1975) in entomology at the Luiz de Queiroz College of Agriculture at the University of São Paulo (ESALQ-USP)

INSTITUTION
Esalq-USP

SCIENTIFIC PRODUCTION
Three hundred and forty-one scientific articles, 20 books written or edited, acted as advisor to 61 master's and 50 doctoral candidates

When he turned 70 at the end of 2014, agricultural engineer José Roberto Postali Parra was required to retire from the Luiz de Queiroz College of Agriculture (ESALQ), a unit of the University of São Paulo (USP) in Piracicaba, where he was director. However, the specialist in the biological control of agricultural pests never considered abandoning his research at the school's Department of Entomology and Acarology. "I have been fighting my whole life, and I'm not going to stop working now that biological controls are gaining ground in Brazilian agriculture," he says. This form of combating pests that affect planted crops uses their own natural enemies, such as insects, mites, and even microorganisms, to combat problems in the fields. Instead of resorting to chemical insecticides, which when used incorrectly can harm humans and the environment, farmers try to destroy or at least reduce the abundance of an attacking pest with the help of a small wasp, for example, or a fungus found in nature.

Parra has dedicated more than four decades of research to understanding the biology of natural enemies of pests and their interactions with the environment for pests such as sugarcane borers and diseases such as the greening of orange groves. He has developed laboratory methods to breed insects and mites proven to help farmers. Parra is thoughtful when he admits that biological control is not the solution for all pests, but the approach can be useful

and help reduce the use of pesticides in agriculture. "Brazil leads the world in the use of chemicals in agriculture," he states. "Our farmers have this culture." In this interview, Parra tells the story of insects and pests in Brazilian farming and comments on topics that are important to agriculture in the country, such as the use of transgenic varieties and the adoption of organic practices.

In which crop are biological controls most commonly utilized in Brazil?
Sugarcane is the classic example. Today, between 9 and 10 million hectares are planted with sugarcane in São Paulo. Nearly half of this area of sugarcane in the state uses biological controls. They are used to combat the moth whose larva is known as the sugarcane borer [*Diatraea saccharalis*] and the spittlebug *Mahanarva fimbriolata*, a pest that attacks the roots of the plant. To destroy the borer caterpillar, the wasp *Cotesia flavipes*, an insect from Trinidad and Tobago that was introduced in the country in 1971, is released. *Cotesia* is used in 3.5 million hectares of sugarcane. The wasp I work with *Trichogramma galloi* has been used to combat borer eggs in approximately 500,000 hectares of sugarcane. Different natural enemies can be used to attack different developmental stages of these insect pests, including eggs, larvae, pupae, and adults. A fungus called *Metarhizium anisopliae* is used to control the spittlebug.

What other crops have used this method?
An interesting story involves the biological control of citrus greening disease, also known in Asia as HLB or *huanglongbing*, which turns the leaves of orange trees yellow and kills the plants. The bacteria *Candidatus liberibacter* causes greening, which is transmitted to plants by a small insect, the psyllid Diaphorina citri. Because of greening, citrus farmers began to apply insecticides to their groves 20 to 30 times a year in an unchecked battle against the psyllid. We tried to use biological controls by releasing small wasps of the species *Tamarixia radiata*, which originates in Asia but was found here in São Paulo. We released the wasps in the groves, but they died. The orchards had citrus greening disease, but they did not have the psyllid *Diaphorina citri*.

"Nearly half of the area of sugarcane in the state of São Paulo uses biological controls. The borer and spittlebug are combated using these methods

Why did the orchards have the disease without the psyllid?
We found that the primary outbreaks of the disease came from areas outside the orchards, from organic areas, from backyards, from myrtle, which is the host plant of the psyllid, and from abandoned orchards. FUNDECITRUS [Brazilian Fund for Citrus Protection] estimated that these neighboring areas totaled 12,000 hectares. We began to release the wasps in these areas to avoid primary outbreaks. The release worked. Today, the Citrosuco Company has five bioproduction centers for the wasps, FUNDECITRUS has another, and a farmer is starting to breed these insects. Now, citrus growers put baits on the edges of their groves as yellow glue traps, which detect the moment that the psyllid arrives in the orchard. In the United States, citrus greening disease has practically wiped out citrus farming in Florida. They knew how to use biological controls but did not use them. They thought that only improving the nutrition of the plant would be sufficient to combat the disease. Alone, biological controls do not solve all the problems and are only one component of IPM, integrated pest management, which appeared in the late 1960s and early 1970s. You must use healthy young trees, remove sick plants, and apply insecticide within reason.

The United States is not prominent in biological pest control?
Actually, they do not use biological controls to the extent that they advocate in the books they publish on the subject. Use of chemicals is also a part of their culture, which is even true in California. IPM was a public policy that began during Richard Nixon's term [1969–1974]. Other presidents came and went, and by the end of the Clinton administration [1983–1992], it was established that 75% of American farmers would have to use IPM. However, they only reached 4 to 8%, demonstrating that transition is not easy. Today, large companies operate in the area of biological control. The leader is Koppert, a Dutch company. Biobest is in second place, from Belgium, and third is BioBee, from Israel. The large multinationals in the area of insecticides, such as Bayer, Syngenta, and Monsanto, now also have companies for biological control. This system is most widely used in Europe, primarily in the Netherlands and Spain. Today is the perfect time for biological control in Brazil. Although I am retired and turned 70 at the end of 2014, I am not going to stop working. I have fought my entire life, and now that biological controls are becoming more established, I am not going to stop.

More recently, a wasp began to be used to fight a caterpillar that attacks various crops in central Brazil. Is the wasp working?
In March 2013, a significant pest appeared in fields in the state of Goiás, the earworm *Helicoverpa armigera*. The earworm attacks up to 200 host plants and affects crops including soy, cotton, oranges, and coffee. This caterpillar cannot be controlled with chemicals. Farmers had to use biological controls, utilizing a virus, NPV, which combats the caterpillar directly or wasps in the

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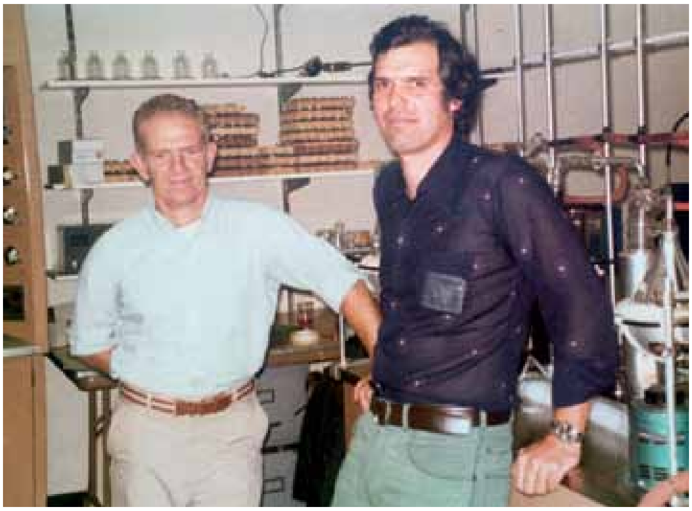

Parra (*right*) at the University of Illinois in 1978, with Marcos Kogan, his postdoctoral supervisor

genus *Trichogramma*, which attack their eggs. The problem is that occasionally the availability of insects is insufficient for everyone to use this method. Now, companies dedicated to providing biological products for this market are beginning to emerge in Brazil. Only within FAPESP's PIPE [Innovative Research in Small Businesses] program, 11 startups involve biological controls. The Bug Company, in Piracicaba, started in my lab. ProMIP, which works mostly with mites, also began in ESALQ, from the work of professor Gilberto Moraes. Young people are very enthusiastic about establishing companies. However, I am worried that if the companies are not professional, they can tarnish the image of biological control. Our work has to be slow but safe, and we cannot rush. When a mistake occurs, farmers will be slow to return to biological control.

Did some event demonstrate this in Brazil?

The fungus *Metarhizium* in the 1970s is an example of such an event. An Italian who was an advisor to the FAO [the United Nations Organization for Food and Agriculture], Pietro Guagliumi, introduced this fungus in the northeast where the sugarcane spittlebug was a problem. However, in the northeast, the problem was more in the leaf of the plant, whereas in São Paulo, it was in the root system. The spittlebugs that cause these problems are very similar. They began to use the fungus in the northeast and it was a success. However, unprofessional companies soon emerged that began to sell contaminated fungi. After that occurred, the biological controls did not work. Years were required before this method was used again not only in the region but across all of Brazil.

What type of agricultural pests can be combated by biological controls and which ones cannot?

IPM works similar to a house that has a foundation composed of some items. You must know the influence of the climate, the pest, and the right time for control. Some people confuse natural enemies with agricultural pests. The natural enemies are also part of this foundation and are responsible for the natural levels of mortality in an agricultural system. Pests have natural enemies, and these natural enemies also have their own natural enemies, describing a trophic chain. Everything would be in balance if we were not planting so much soy and sugarcane to meet human food requirements. Monocultures cause imbalances. On top of the house's foundation are the methods of controlling pests, such as biological control, which can also use pheromones, planting different crops, chemical products, and transgenic plants. All these measures are intended to maintain pests at a level below economic damage, accounting for social and ecological criteria in addition to the economic aspect. As I said, biological control is not the solution for all problems. Some crops can use additional biological control, whereas other crops will use less. In crops with many insects, the use of biological controls is difficult. In this case, the solution is to use selective chemicals that kill the pest but not its natural enemies. Tables are available to farmers that recommend these products for a variety of situations. In some crops, such as potatoes, tomatoes, and even cotton, Brazilian farmers use large amounts of insecticide.

Is this more of an economical or cultural question?

Brazil leads the world in the use of chemicals in agriculture. The country has an exclusively chemical culture, something that is difficult to change, which is the big problem. Farmers say that their fathers and grandfathers always used insecticides and want to see the insect that is attacking the crops dead on the ground after they apply the pesticide. We have less of a tradition of biological control than other Latin American countries such as Peru, Colombia, and Venezuela, which were highly motivated by researchers from California. Those working with chemicals significantly influenced our agriculture. DDT was synthesized in 1939, and everyone imagined that all the problems in agriculture were solved. Then, serious problems emerged, such as biological imbalances and water pollution. The American biologist Rachel Carson wrote a famous book on this topic in 1962, *Silent Spring*. From 1940 to 1960, biological pest control went through a dark time. Then, IPM arose as the scientific community's response to the inappropriate use of pesticides, which is a way of controlling pests that accounts for the economic aspects (which cannot be ignored), as well as the ecological and social aspects.

When did biological control emerge?

Biological control is thousands of years old. The Chinese used natural enemies to control citrus pests before Christ was born. Biological control, as we know it today, actually began in 1888 in California. Riverside and Berkeley are the two major centers. The area had a serious citrus pest, the cottony cushion scale, which is actually a scale insect, *Icerya purchasi*. The Americans went to Australia, which is where the insect most likely originated, obtained the Vedalia beetle (*Rodolia cardinalis*) and introduced it in California. The following year, the case was considered a success. We imported the first insect to Brazil in 1921. In São Paulo, an American wasp was introduced, which parasitizes the white

Parra with students at the University of São Paulo in 2004

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peach scale insect. However, the introduction failed. Several similar episodes occurred like that. Around 1924, the coffee berry borer appeared, *Hypothenemus hampei*, a small beetle from Africa that attacks this crop. Researchers from the Biological Institute and a professor at ESALQ, Salvador de Toledo Piza Junior, went to Africa and brought a wasp from Uganda, *Prorops nasuta*; however, control of the pest was not very successful. Coincidentally, approximately 20 years ago, some researchers came to me because this wasp was found in the region of Ribeirão Preto. They wanted to reproduce the wasp, and as a result, techniques are available today to breed them.

At that time, was the technique to breed this wasp also imported?

At that time, no breeding technique was available. This period was the time of so-called classical biological control, when everything was performed in a rudimentary form and some insects could be bred on a small scale without any technology. Researchers went to the origin of the pest, obtained the natural enemies, and introduced them into the plantations that had the problem. Because no techniques existed to breed the insects, few natural enemies were introduced. This type of introduction is consequently called inoculative release. When only a few are released, the response is not immediate, and the insects must multiply in nature. This situation created an image that biological controls only produce a long-term outcome, in perennial or semiperennial crops. Today, native enemies are more widely used, because many restrictions are placed on importing insects.

You have a patent for the production of a semiochemical, a sexual pheromone used to control a citrus pest. How did this come about?

The one who works with pheromones is José Maurício Simões Bento, my department colleague at ESALQ and vice-coordinator of the National Institute of Science and Technology for Semiochemicals in Agriculture, where I am a coordinator. We have a patent for the pheromone used to control the moth *Gymnandrosoma aurantianum*, which is known as the citrus fruit borer. This moth lays its eggs on the fruit, and when they hatch, the caterpillars feed in the oranges, which rot and drop. The female of this species produces a substance, a pheromone, which attracts the male for mating. We studied the sexual behavior of females to know where they mate in the tree and learned to synthesize this pheromone in the laboratory. We created a trap with a tablet that gradually releases this synthesized substance, and we put these traps in the orange trees. Thus, we deceive the males and attract them to the trap. Our partners at the University of Tsukuba in Japan created this tablet. The tablet is enclosed in plastic, a great technological idea, which controls the release of the substance over 30 days. If you remove the plastic, all the pheromone is released in one day. Some farmers remove the plastic and then complain that the method does not work. We had to give seminars to convince people not to remove the plastic. Over the 10 years during which this biological control method has been used, which cost US$50,000 for development, farmers in São Paulo saved US$1.3 billion on unnecessary application of insecticides.

Do these cases of economically successful control stimulate research in the area?

The other day I was talking with the president of Koppert, a company with a presence in 27 countries that has a subsidiary in Piracicaba. He told me that biological control is used in 90 or 95% of greenhouses in the Netherlands. These are large greenhouses, covering 10 or 20 hectares. However, that situation cannot be compared with Brazil. Here, in the Midwest, for example, a single producer might have 100,000 hectares of soybeans. I always say in lectures that Brazil is undisputedly the leader in tropical agriculture. However, because of our large size, tropical agriculture is cruel for biological controls. We must develop a model for tropical biological control. We cannot manually release insects over 100,000 hectares; a drone or a plane must be used. You cannot walk through 100,000 hectares of soybeans to know when is the right time to release the insects; remote sensing is required to track the timing. We remain in early days in this regard, but our biological control programs are among the largest in the world in terms of area managed.

How did your interest in entomology come about?

I completed the scientific track [one of the variations in the old high school curriculum, with an emphasis on the exact and natural sciences], and I had very strong leanings toward the area of biology and imagined I would be a doctor. I lived in Campinas, in the neighborhood of the IAC [the Agronomy Institute]. My house was the first one after the IAC. In the last year of the scientific program, I went on a field trip to ESALQ and fell in love with the school. I did the prep course and went to study agronomy there in 1964, always with the idea that I would stay at the IAC. During college, I went to the institute on weekends and holidays when I was in Campinas. In my second year of agronomy, I began to work with entomology. I received a scientific initiation scholarship from CNPq [the Brazilian National Council of Scientific and Technological Development]. When I graduated in 1968, I even had a few published articles. I entered the IAC six months after graduating, after a competitive examination process.

In the IAC were they already working with biological controls?
I started in a slightly different area, plant resistance to insects, with the cotton root borer [*Eutinobothrus brasiliensis*]. I did my master's there but went to ESALQ. I was looking for a genotype of cotton that was resistant to the borer. However, I ended up leaving the area of entomology and went over to climatology at the IAC to study the influence of climatic factors on insect development. While I was still working at IAC, I also did my doctorate at ESALQ on the coffee leaf miner, the moth *Leucoptera coffeella*, which attacks the leaves of this crop. In 1974, I was invited to go to ESALQ. At that time, no competitive process was in place for the university. I accepted the invitation and began to work on insect biology. Then, in 1977 and 1978, my postdoctoral studies were conducted at the University of Illinois in the United States. After completing those studies, I returned to Brazil and began to work with biological controls. At ESALQ, a tradition of biological control in entomology already existed. The head, professor Domingos Galo, had previously used biological control in the cultivation of sugarcane. During my postdoc in the United States, I studied artificial diets for insects. In Brazil, I was a pioneer in this area, which is the foundation for biological control. To create natural enemies, you must know how to raise the pests. I developed this area, which had been essentially prohibited in Brazil because all the components were imported. I had to develop breeding technology that was adapted to our conditions.

Today, are there laws governing the use of biological controls in Brazil?
Because of so much ignorance, our laws are entirely based on the use of chemicals. They even wanted to put a skull on biological products, similar to the labeling of chemicals. The approval process is time consuming but is improving. Today, 41 biological products are waiting for approval by the three public bodies responsible for this process: MAPA [the Brazilian Ministry of Agriculture, Livestock and Supply], ANVISA [the Brazilian Health Regulatory Agency], and IBAMA [the Brazilian Institute of the Environment and Renewable Natural Resources]. Additionally, an entity is included that brings together companies from the sector, the Brazilian Association of Biological Control, better known as ABCBio, for which I am a member of the technical committee. We advise on how to perform quality control in this sector. We cannot leave this responsibility to the companies, and it must be performed by an agency linked to a university or to some research center. Today, still, no independent quality control for biological products exists.

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Brazil has a culture of using chemical products. Farmers say that their fathers and grandfathers used insecticides

Are you part of any of these companies?
No. I followed and encouraged the formation of Bug. Across Brazil, everyone says I am the owner of the company because it was the product of ex-students and a technician who worked in my lab. Today, several companies operate, and my only connection with all of them is scientific.

What do you think about organic agriculture?
Organic agriculture may have its place. Today, even large economic groups are in this sector. However, I think a lack of knowledge exists about who is practicing this type of agriculture. Not many possibilities are available to be exclusively organic. People have many questions. However, it is an interesting market, with potential. A lack of research defines this area, leading to much romance, poetry, and ideology.

Do organic producers use biological controls?
As far as I know, they use very little. Organic producers talk a lot about biological controls, but they are not used very much.

Do you think that organic farming could be an alternative for large-scale production, or does it lend itself to small projects?
Organic farming faces the challenges of developing tropical biological controls. Because organic areas are not that large, the use of biological control in these properties would be even easier. However, in organic agriculture, problems are related to plant growth, because fertilizers are not used and the crop is less vigorous. Not using inputs leads to other problems that must be solved, and biological control is ultimately unnoticed. Few people around the world are conducting research on organic agriculture.

Are you in favor of transgenic crops?
According to the current scientific literature, no harm has been attributed to transgenics. I think that transgenics are a control method similar to any other, but they have a limited period of validity. In a very short time, transgenic-resistant insects are selected and another transgenic will be required, with old crop varieties being replaced with newer, more pest-resistant varieties. I am not against transgenics; I am against assuming they are the solution to all our problems. Transgenic sugarcane will not be the end of biological control in this sector, as some say. Resistant pests always emerge. Transgenic soy controls the earworm *Helicoverpa armigera*, but not stinkbugs or other pests. For these pests, some other biological measure will be required. ■