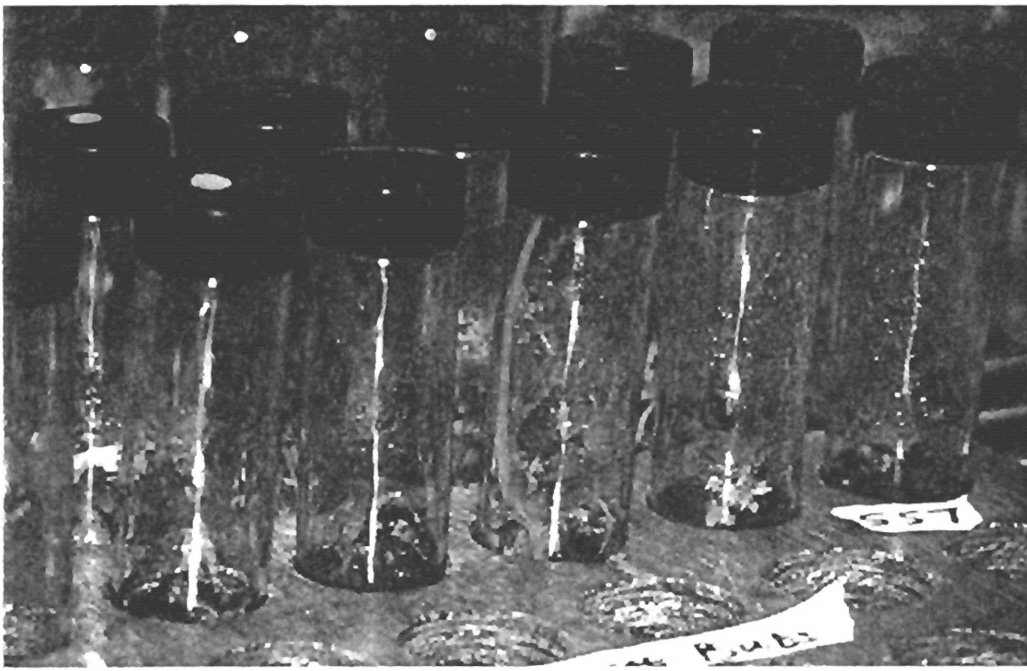
Deutsche Stiftung für internationale Entwicklung
German Foundation for International Development

Jürgen Richter, Jürg Huber, Bruno Schuler (eds.)

Biotechnology for Crop Protection – its Potential for Developing Countries

Proceedings of an International Workshop
held from 9th – 13th December 1996 in Berlin, Germany

Rapporteur: Dr. Dagmar Jördens-Röttger



Zentralstelle für Ernährung und Landwirtschaft (ZEL) - Feldafing/Zschortau
Food and Agriculture Development Centre

Published by:
Deutsche Stiftung für internationale Entwicklung (DSE)
Zentralstelle für Ernährung und Landwirtschaft
Phone: (*49) 8157 – 9380; Fax: (*49) 8157 – 938777
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DOK 1801a
IT 711-318-96
ISBN 3-931227-37-5

Cover photo by B. Schuler: Biotechnical applications at the Institut de la Recherche Agronomique pour le Développement (IRAD), Cameroon

Print:
Proff Offsetdruck, D- 82547 Eurasburg
May 1998

Gedruckt auf holzfreiem, säurefreiem, chlorfrei gebleichtem und alterungsbeständigem Papier.

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Biotechnology and Crop Protection in Brazil

Clayton Campanhola[1]*; Geraldo Stachetti Rodrigues*[2] *& Wagner Bettiol*[3]

1. Introduction

The process of modernisation of Brazilian agriculture aimed at increasing the productivity in response to the high demand for agricultural products in the world market and it was based on the intensive use of inputs such as agrochemicals, intense mechanisation and breeding of new varieties. Among these, pesticides were incorporated in almost all production systems. Over reliance on pesticide use has produced many negative effects on both biotic and abiotic components of the environment, generating chemical contamination of soil and water, decrease in biological diversity of agro-ecosystems, disruption of natural cycles, pest resistance, intoxication of growers, among others.

The consumption of pesticides in Brazil was 151.8 thousand tonnes in 1989, and today the country is the fifth biggest world market for these products. The use of pesticides increased from 16 thousand tonnes (a.i.) in 1964 to 60.2 thousand tonnes in 1991, while the area planted to crops grew from 28.4 to 50.0 million ha in the same period. This means an increase of 276.2% in consumption of pesticides compared to an increase of 76% in planted area. Even with this large increase in the use of pesticides, the losses caused by pests have not been significantly reduced, and the net gain in crop productivity has been low. On the other hand, problems with food contamination, environmental degradation, and intoxication of growers have considerably mounted.

It is possible to define two classes of crops regarding the intense use of pesticides. One is represented by those crops that occupy large areas, and therefore contribute to a large amount of pesticides used for pest control in a country basis. The other class comprises crops that require large amounts of pesticides per unit of area, but not necessarily represent large amounts of pesticides used country-wide.

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Crop	Amount in tonnes	% of Total
Citrus	11,154	17.5
Soy bean	9,929	15.6
Sugarcane	6,211	9.8
Corn	4,423	6.9
Potato	3,450	5 4
Cotton	3,405	5.3
Tomato	2,109	3.3
Total consumption per year	63,610	100.0

Table 1: Consumption of pesticides in some Brazilian crops, in amount of active ingredient, 1990.

Based on the classes proposed, citrus, soy bean and sugarcane stand as crops with a nationally great consumption of pesticides. while tomato, potato and citrus are important as intensive users of pesticides (Tables 1 and 2).

The use of alternative crop protection practices raises two main benefits given a decrease in the use of pesticides. First, reductions in the use of pesticides in crops with large planted areas can bring real gains in terms of financial savings and of conservation of the environment as a whole. Second, for crops with intensive use of pesticides, curtailment of application can result in significant benefits such as the lowering of chemical residue levels in agricultural products and improving safety to field workers.

Crop	Amount kg/ha
Tomato	39.5
Potato	21.8
Citrus	12.2
Cotton	2.4
Sugarcane	1.6
Soy bean	0.9
Corn	0 4

Data obtained from Spadotto et al. (1996). in XIII Congresso Latino Americano de Ciencia do Solo. 4 a 8 de agosto. Aguas de Lindoia, SP. CD-ROM.

Table 2: Consumption of pesticides per unit of area in some Brazilian crops, in amount of active ingredient. 1990.

The Brazilian government, concerned with the adverse effects of pesticides observed over the years on environment and on man, urged its official agencies

and organisations to elaborate a national programme for the rationalisation of pesticide use in agriculture. The provisions of this programme are currently under discussion and will consist primarily of incentives for the use of crop protection practices alternative to pesticides. The programme spans the promotion of research and development of new technology and production systems, technology transfer efforts, and introduction of appropriate policies and regulations.

This paper presents the biotechnologies for pest control available in Brazil that can partially or totally replace pesticides. Some of these practices still require efforts for diffusion and transference to growers for their more effective practical utilisation.

2. Biotechnologies in Use

2.1 Insect Pest Control

2.1.1 Biological Control

2.1.1.1 In sugarcane

Control of sugarcane borer, *Diatraea saccharalis*, with the parasitoid wasp *Cotesia flavipes*, in the total area planted to sugarcane (4.5 million ha). Since 1975 the wasp has been mass-produced and released to fields as a coordinated action of sugarcane mills. In addition, the dipteran parasitoids *Paratheresia claripalpis* and *Metagonistvlum minense* are also in use (Campanhola et al. 1995).

Control of sugarcane plant hopper, *Mahanarva posticata*, with the fungus *Metarhizium anisopliae* has been successful for 20 years in north eastern Brazil. This programme covers an area of 150,000 ha. A commercial fungal product has been supplied by IPA (State of Pernambuco Agricultural Research Corporation) and private laboratories (Campanhola et al. 1995)

2.1.1.2 In soy bean

Control of velvet bean caterpillar, *Anticarsia gemmatalis*, with a polyhedrosis virus (NPV), *Baculovirus anticarsia*, is in use in over 1 million ha, which represent 10% of the national area planted to soy bean, and resulting in savings with pesticides of about US$ 50 million a year. Production and commercialisation of the virus has been carried out by EMBRAPA's National Research Centre on Soy Bean (CNPSo).

Control of the true bugs, *Nezara viridula* and *Piezodorus guildinii*, with the egg parasitoid wasp, *Trissolcus basalis*. is increasing every year. Full adoption of these control tactics by growers may represent savings of 7.5 million litres of pesticides and of over US$ 70 million per year. This is also an effort of the CNPSo.

2.1.1.3 In grasslands

Control of leafhoppers with the fungus *Metarhizium anisopliae*. An area of 25,000 ha has been treated yearly, with a single 1 kg dose of Metabiol, a formulation for the spores. The use of this pathogen eliminates the need for 5 insecticide applications per year.

2.1.1.4 In tomato

Control of the leaf miner/fruit borer, *Tuta (Scrobipalpuloides) absoluta*, with the parasitoid wasp *Trichogramma pretiosum*. Since the introduction of this pest in north eastern Brazil in 1981, the damage caused has amounted to 140,000 tonnes of tomatoes equivalent to economic losses of about US$ 8 million. Periodical release of laboratory-produced wasps has been acknowledged as the most outstanding technique in the IPM implemented for this pest. Actions for this programme are under coordination of EMBRAPA's Agricultural Research Centre on the Semi-arid Region in collaboration with several private laboratories (Campanhola et al. 1995).

2.1.1.5 In rubber trees

Control of *Leptophensa heveae* (Hemiptera, Tingidae) with the fungi *Hirsutella verticillioides* and *Sporothrix insectorum*, reaching up to 50,000 ha yearly.

2.1.1.6 In banana

Control of the borer *Cosmopolites sordidus* (Coleoptera, Curculionidae) with the fungus *Beauveria bassiana* in north eastern Brazil. IPA (State of Pernambuco Agricultural Research Corporation) has produced and distributed the fungus to the growers in the last 15 years. With this control, reduction in the use of insecticides has been estimated in 75%.

2.1.1.7 In rice

Control of *Diatraea saccharalis* with the same parasitoid, *Cotesia flavipes*, used in sugarcane.

Control of a virus vector, *Deois flavopicta* (Coleoptera, Chrysomelidae), with *Metarhizium anisopliae*.

2.1.1.8 In alfalfa

Control of the aphids *Acyrtosiphon kondoi* and *A. pisum* with the parasitoid wasps *Aphidius smith* and *Ephedrus plagiator*.

2.1.1.9 In sunflower

Control of *Rachiplusia nu* and *Chlosyne lacinia saundersii* with *Bacillus thuringiensis*.

2.2 Plant Pathogen Control

2.2.1 Biological Control

2.2.1.1 In citrus

Mild strains of Tristeza virus of citrus for the control of Tristeza virus through pre-immunisation or cross protection. Pre-immunised plants started to being used in 1971, reaching around 100 million cross-protected sweet orange trees on commercial orchards of Sao Paulo State today. This technology was developed at the Agronomic Institute of the State of Sao Paulo (Bettiol 1996).

2.2.1.2 In coconut

Use of the mycoparasites *Acremonium alternatum* and *Acremonium persicinum* for the control of tar spot of coconut (*Catacauma torrendiella* and *Coccostroma palmicola*). There is no need for reapplication of the parasite and just one application at the beginning of fruiting is enough to control the disease permanently. Five or more applications of fungicides are necessary instead to attain control of the pathogen. In addition one application of the antagonist costs five times less than one fungicide application (Sudo 1989).

2.2.1.3 In apple tree

Control of *Phytophthora cactorum* (root rot disease) with *Trichoderma viride*. Best results are obtained with the desinfestation of the substrate with formaldehyde before the incorporation of *T. viride*. The final commercial product contains sterilised sorghum seeds, colonised with metalaxyl-resistant *T. viride*. This product has been sold since 1987 by EMBRAPA (Brazilian Agricultural Research Corporation) at the rate of approximately 50,000 bags of 24g each per year (Bettiol 1996).

2.2.1.4 In strawberry

Control of *Botrytis cinerea* (gray mould) in greenhouses with the fungus *Gliocladium roseum*. The commercialisation of a product containing wheat seeds colonised by *G. roseum* was initiated in July 1995. The control is as effective as fungicide application (Bettiol 1996).

2.2.1.5 In tobacco

Control of damping-off with mass application of an antagonistic fungus, *Trichoderma*, multiplied in wheat grains.

2.2.2 Genetic Control

This is the most practical and cheapest method to overcome plant diseases. In spite of the advantages, many breeding programmes still emphasise productivity and aesthetics demanded by the market, instead of genetic resistance to diseases.

Even with the inadequate attention that has been paid to genetic resistance research, there are many cases of cultivated plant varieties expressing resistance to pathogens. A good example of genetic control in Brazil is the introduction of numerous resistant varieties of cow pea to different diseases. This technology contributed to the elimination of 5-7 fungicide applications that were necessary prior to the generalised use of resistant varieties.

3. Biotechnologies in Advanced Stages of Development

Examples of technologies that are under development but for several reasons have not been adopted in the field are presented next. There are many other cases of ongoing research projects dealing with resistant varieties to plant pathogens, but since they are locally oriented, we decided to mention only a few.

3.1 Insect Pest Control

Biological control of fruit flies *(Anastrepha spp)* with the parasitoid wasps *Diachosminorpha longicaudata* (Hymenoptera, Braconidae) and *Doryctobracon areolatus* (Hymenoptera, Braconidae) (EMBRAPA's National Research Centre on Cassava and Tropical Fruits - CNPMF)

Control of the scale *Orthezia praelonga* with the fungus *Colletotrichum gloeosporioides* and *Beauveria bassiana*. (EMBRAPA's National Research Centre on Cassava and Tropical Fruits - CNPMF and EMDAGRO - State of Sergipe Agricultural Development Corporation).

Control of *Erinnyis ello* with *Baculovirus erinnyis* (EMBRAPA's National Research Centre on Cassava and Tropical Fruits - CNPMF and EPACE - State of Ceara Agricultural Research Corporation).

Use of *Baculovirus spodoptera* to control the armyworm *Spodoptera frugiperda* in maize (EMBRAPA's National Research Centre on Maize and Sorghum - CNPMS).

Use of the wasp *Trichogramma spp.* to control the tobacco budworm, *Heliothis virescens* and the leaf worm, *Alabama argillacea*, in cotton (EMBRAPA's National Research Centre on Cotton - CNPA)

Use of the fungi *Beauveria brongniartii* and *B. bassiana* to control a leaf worm of coconut. *Brassolis sophorae*. (EMBRAPA's Agricultural Research Centre of the Coastal Lowland Region - CPATC)

3.2 Plant Pathogen Control

Use of *Bacillus subtilis* for the control of coffee and bean rust, and powdery mildew on cucumber and zucchini squash. (EMBRAPA's National Research Centre for Environmental Monitoring and Impact Assessment) (Bettiol 1996).

Wheat seed microbial colonisation with *Pseudomonas fluorescens* and several non-identified bacteria as antagonists to common root rot (Luz 1993).

Use of *Trichoderma harzianum* for the control of lettuce drop (*Sclerotinia*). Pellets containing structures of benomyl-resistant *T. harzianum*, kaolin, and alginate were used after benomyl application, causing a reduction of about 50% in diseased plants. This efficiency is improved with successive plantings (I. S. de Melo EMBRAPA/CNPMA, personal communication).

Development of transgenic plants of potato with multiple resistance to viral infection caused by the viruses PVX, PVY, PLRV (EMBRAPA's National Research Centre on Biotechnology and Genetic Resources - CENARGEN).

Genetic resistance of sugarcane to smut (*Ustilago scitaminae*) and to rust (*Puccinia melanocephala*).

Genetic resistance of rice varieties to bacterial diseases.

3.3 Weed Control

Development of a transgenic soy bean variety resistant to the herbicide glyphosate. It has the potential for being sown in one million ha in southern Brazil, in association with no-tillage agriculture. (EMBRAPA's National Research Centre on Soy Bean and Monsanto).

4. Main Constraints to the Development and Use of Biotechnology

Low emphasis on the inclusion of resistance to insect pests and to plant pathogens in the plant breeding programmes and research projects.

Lack of specific and strong national policies to promote the use of biological control agents and biotechnology for crop protection.

Absence of regulations for intellectual property rights and patenting. Presently, a patenting system is being implanted in Brazil and a plant variety protection act is in negotiation in parliament.

Low interest of industry to explore production and commercialisation of biological control agents, because of the restricted market for these products.

Lack of a specific legislation for registration of biological products, which could facilitate and expedite processing and decrease registration costs and paperwork.

Inefficiency of the official extension service to promote and transfer knowledge and technologies, with special regard to biotechnology products, to the different categories of growers.

Low concern of growers with use of alternative practices for crop protection and with environmental quality and its conservation.

Need for improved laboratory facilities to promote widespread research and development on biotechnology.

Need for enhancement in the formulation of products based on microorganisms and biological materials to facilitate their use as biological control agents

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