

TOPICS IN

AGRICULTURAL ENTOMOLOGY

XIII

JOACIR DO NASCIMENTO | CLAUDIANE MARTINS DA ROCHA
DANIEL DALVAN DO NASCIMENTO | EDIMAR PETERLINI
ÉRICA AYUMI TAGUTI | JOAO RAFAEL SILVA SOARES
MATHEUS CARDOSO DE CASTRO | SANDY SOUSA FONSÊCA
VINICIUS FERRAZ NASCIMENTO | RICARDO ANTONIO POLANCZYK
(ORGANIZADORES)



TOPICS IN

AGRICULTURAL ENTOMOLOGY XIII

JOACIR DO NASCIMENTO | CLAUDIANE MARTINS DA ROCHA
DANIEL DALVAN DO NASCIMENTO | EDIMAR PETERLINI
ÉRICA AYUMI TAGUTI | JOAO RAFAEL SILVA SOARES
MATHEUS CARDOSO DE CASTRO | SANDY SOUSA FONSÊCA
VINICIUS FERRAZ NASCIMENTO | RICARDO ANTONIO POLANCZYK
(ORGANIZADORES)



Editora chefe

Profª Drª Antonella Carvalho de Oliveira

Editora executiva

Natalia Oliveira

Assistente editorial

Flávia Roberta Barão

Bibliotecária

Janaina Ramos

Projeto gráfico

Bruno Oliveira

Camila Alves de Cremo

Daphynny Pamplona

Luiza Alves Batista

Natália Sandrini de Azevedo

Imagens da capa

iStock

Edição de arte

Luiza Alves Batista

2022 by Atena Editora

Copyright © Atena Editora

Copyright do texto © 2022 Os autores

Copyright da edição © 2022 Atena Editora

Direitos para esta edição cedidos à Atena Editora pelos autores.

Open access publication by Atena Editora



Todo o conteúdo deste livro está licenciado sob uma Licença de Atribuição *Creative Commons*. Atribuição-Não-Comercial-NãoDerivativos 4.0 Internacional (CC BY-NC-ND 4.0).

O conteúdo dos artigos e seus dados em sua forma, correção e confiabilidade são de responsabilidade exclusiva dos autores, inclusive não representam necessariamente a posição oficial da Atena Editora. Permitido o *download* da obra e o compartilhamento desde que sejam atribuídos créditos aos autores, mas sem a possibilidade de alterá-la de nenhuma forma ou utilizá-la para fins comerciais.

Todos os manuscritos foram previamente submetidos à avaliação cega pelos pares, membros do Conselho Editorial desta Editora, tendo sido aprovados para a publicação com base em critérios de neutralidade e imparcialidade acadêmica.

A Atena Editora é comprometida em garantir a integridade editorial em todas as etapas do processo de publicação, evitando plágio, dados ou resultados fraudulentos e impedindo que interesses financeiros comprometam os padrões éticos da publicação. Situações suspeitas de má conduta científica serão investigadas sob o mais alto padrão de rigor acadêmico e ético.

Conselho Editorial**Ciências Agrárias e Multidisciplinar**

Prof. Dr. Alexandre Igor Azevedo Pereira – Instituto Federal Goiano

Profª Drª Amanda Vasconcelos Guimarães – Universidade Federal de Lavras

Profª Drª Andrezza Miguel da Silva – Universidade do Estado de Mato Grosso

Prof. Dr. Arinaldo Pereira da Silva – Universidade Federal do Sul e Sudeste do Pará

Prof. Dr. Antonio Pasqualetto – Pontifícia Universidade Católica de Goiás

Profª Drª Carla Cristina Bauermann Brasil – Universidade Federal de Santa Maria



Prof. Dr. Cleberton Correia Santos – Universidade Federal da Grande Dourados
Prof^o Dr^a Diocléa Almeida Seabra Silva – Universidade Federal Rural da Amazônia
Prof. Dr. Écio Souza Diniz – Universidade Federal de Viçosa
Prof. Dr. Edevaldo de Castro Monteiro – Universidade Federal Rural do Rio de Janeiro
Prof. Dr. Fábio Steiner – Universidade Estadual de Mato Grosso do Sul
Prof. Dr. Fágner Cavalcante Patrocínio dos Santos – Universidade Federal do Ceará
Prof^o Dr^a Girlene Santos de Souza – Universidade Federal do Recôncavo da Bahia
Prof. Dr. Guilherme Renato Gomes – Universidade Norte do Paraná
Prof. Dr. Jael Soares Batista – Universidade Federal Rural do Semi-Árido
Prof. Dr. Jayme Augusto Peres – Universidade Estadual do Centro-Oeste
Prof. Dr. Júlio César Ribeiro – Universidade Federal Rural do Rio de Janeiro
Prof^o Dr^a Lina Raquel Santos Araújo – Universidade Estadual do Ceará
Prof. Dr. Pedro Manuel Villa – Universidade Federal de Viçosa
Prof^o Dr^a Raissa Rachel Salustriano da Silva Matos – Universidade Federal do Maranhão
Prof. Dr. Renato Jaqueto Goes – Universidade Federal de Goiás
Prof. Dr. Ronilson Freitas de Souza – Universidade do Estado do Pará
Prof^o Dr^a Talita de Santos Matos – Universidade Federal Rural do Rio de Janeiro
Prof. Dr. Tiago da Silva Teófilo – Universidade Federal Rural do Semi-Árido
Prof. Dr. Valdemar Antonio Paffaro Junior – Universidade Federal de Alfenas



Topics in agricultural entomology - XIII

Diagramação: Natália Sandrini de Azevedo
Correção: Yaidy Paola Martinez
Indexação: Amanda Kelly da Costa Veiga
Revisão: Os autores

Dados Internacionais de Catalogação na Publicação (CIP)

T674 Topics in agricultural entomology - XIII / Joacir do Nascimento, Claudiane Martins da Rocha, Daniel Dalvan do Nascimento, et al. – Ponta Grossa - PR: Atena, 2022.

Outros organizadores
Edimar Peterlini
Érica Ayumi Taguti
João Rafael Silva Soares
Matheus Cardoso de Castro
Sandy Sousa Fonsêca
Vinicius Ferraz Nascimento
Ricardo Antonio Polanczyk

Formato: PDF
Requisitos de sistema: Adobe Acrobat Reader
Modo de acesso: World Wide Web
Inclui bibliografia
ISBN 978-65-258-0544-3
DOI: <https://doi.org/10.22533/at.ed.443220109>

1. Agricultura. I. Nascimento, Joacir do (Organizador). II. Rocha, Claudiane Martins da (Organizadora). III. Nascimento, Daniel Dalvan do (Organizador). IV. Título.

CDD 338.1

Elaborado por Bibliotecária Janaina Ramos – CRB-8/9166

Atena Editora
Ponta Grossa – Paraná – Brasil
Telefone: +55 (42) 3323-5493
www.atenaeditora.com.br
contato@atenaeditora.com.br



Atena
Editora
Ano 2022

DECLARAÇÃO DOS AUTORES

Os autores desta obra: 1. Atestam não possuir qualquer interesse comercial que constitua um conflito de interesses em relação ao artigo científico publicado; 2. Declaram que participaram ativamente da construção dos respectivos manuscritos, preferencialmente na: a) Concepção do estudo, e/ou aquisição de dados, e/ou análise e interpretação de dados; b) Elaboração do artigo ou revisão com vistas a tornar o material intelectualmente relevante; c) Aprovação final do manuscrito para submissão; 3. Certificam que os artigos científicos publicados estão completamente isentos de dados e/ou resultados fraudulentos; 4. Confirmam a citação e a referência correta de todos os dados e de interpretações de dados de outras pesquisas; 5. Reconhecem terem informado todas as fontes de financiamento recebidas para a consecução da pesquisa; 6. Autorizam a edição da obra, que incluem os registros de ficha catalográfica, ISBN, DOI e demais indexadores, projeto visual e criação de capa, diagramação de miolo, assim como lançamento e divulgação da mesma conforme critérios da Atena Editora.



DECLARAÇÃO DA EDITORA

A Atena Editora declara, para os devidos fins de direito, que: 1. A presente publicação constitui apenas transferência temporária dos direitos autorais, direito sobre a publicação, inclusive não constitui responsabilidade solidária na criação dos manuscritos publicados, nos termos previstos na Lei sobre direitos autorais (Lei 9610/98), no art. 184 do Código Penal e no art. 927 do Código Civil; 2. Autoriza e incentiva os autores a assinarem contratos com repositórios institucionais, com fins exclusivos de divulgação da obra, desde que com o devido reconhecimento de autoria e edição e sem qualquer finalidade comercial; 3. Todos os e-book são *open access*, *desta forma* não os comercializa em seu site, sites parceiros, plataformas de *e-commerce*, ou qualquer outro meio virtual ou físico, portanto, está isenta de repasses de direitos autorais aos autores; 4. Todos os membros do conselho editorial são doutores e vinculados a instituições de ensino superior públicas, conforme recomendação da CAPES para obtenção do Qualis livro; 5. Não cede, comercializa ou autoriza a utilização dos nomes e e-mails dos autores, bem como nenhum outro dado dos mesmos, para qualquer finalidade que não o escopo da divulgação desta obra.



The authors are grateful to the São Paulo Research Foundation (FAPESP) for the grant 2022/04343-9

PREFACE

The Graduate Program in Agronomy (Agricultural Entomology) at the UNESP Faculty of Agricultural and Veterinary Sciences in Jaboticabal has always been characterized by its focus on Integrated Pest Management (IPM). Since its foundation, the program has graduated 287 students with a master's degree and 148 Ph.D. students. They are now active in various areas of the public or private sector and contribute to agriculture's economic and environmental sustainability.

This e-book entitled "Topics in Agricultural Entomology - XIII" was made possible through the immense effort of the Organizing Committee, formed by MSc and Ph.D. students from all research areas of our Graduate Program. In its 14 chapters, readers will find information on the most diverse areas of IPM, with a richness of information on both the fundamental and applied aspects of IPM.

As coordinator of the 2022 edition of the Winter Workshop on Agricultural Entomology, it is my pleasure to provide event attendees with an e-book of excellent content, demonstrating the importance of our research to society.

Prof. Ricardo Antônio Polanczyk

FCAV/UNESP

PPG Entomologia Agrícola Coordinator

SUMÁRIO

CAPÍTULO 1..... 1

QUALITY CONTROL IN MASS REARING OF INSECTS


Matheus Moreira Dantas Pinto
Dagmara Gomes Ramalho
Brenda Karina Rodrigues da Silva
Joice Mendonça de Souza
Marcelle Bezerra Silva
Thiago Nascimento de Barros
Sergio Antonio de Bortoli

 <https://doi.org/10.22533/at.ed.4432201091>

CAPÍTULO 2..... 18

CONSERVATION PRACTICES FOR MAINTENANCE OF NATURAL ENEMIES IN AGROECOSYSTEMS


Iwlianny Luiza Pereira dos Santos
Vinicius Ferraz Nascimento
Dagmara Gomes Ramalho
Letícia Barbosa de Lacerda
Márcio Aparecido de Melo
Pedro Gomes Peixoto
Sergio Antonio de Bortoli

 <https://doi.org/10.22533/at.ed.4432201092>

CAPÍTULO 3..... 36

IMPLEMENTATION CHALLENGES OF INTEGRATED PEST MANAGEMENT PROGRAMS IN AGRICULTURAL SYSTEMS


Marcelo Coutinho Picanço
Mayara Moledo Picanço
Ricardo Siqueira da Silva

 <https://doi.org/10.22533/at.ed.4432201093>

CAPÍTULO 4..... 43

LANDSCAPE STRUCTURE AND INSECT PEST MANAGEMENT


João Rafael Silva Soares
Sabrina Juvenal de Oliveira
Thaynara Arantes Soares Junqueira
Marina Guimarães Brum de Castro
Yasmin Esteves Izidro
Odair Aparecido Fernandes

 <https://doi.org/10.22533/at.ed.4432201094>

CAPÍTULO 5..... 59

TECHNOLOGICAL INNOVATIONS APPLIED TO INSECT PEST MANAGEMENT


Sandy Sousa Fonsêca
Ciro Pedro Guidotti Pinto
Ana Letícia Zéro dos Santos
Amanda Cristina Guimarães Sousa
Nicole de Paula Souza
Guilherme Duarte Rossi

 <https://doi.org/10.22533/at.ed.4432201095>

CAPÍTULO 6..... 71

GOOD PRACTICES IN AGRICULTURAL SPRAYING FOR PEST MANAGEMENT


Edimar Peterlini
Ana Beatriz Dilena Spadoni
Gabriela Pelegrini
Maria Thalia Lacerda Siqueira
Pedro Henrique Urach Ferreira
Marcelo da Costa Ferreira

 <https://doi.org/10.22533/at.ed.4432201096>

CAPÍTULO 7..... 83

RESISTANCE OF CITRUS PEST MITES TO ACARICIDES


Claudiane Martins da Rocha
Matheus Cardoso de Castro
Daniel Júnior de Andrade

 <https://doi.org/10.22533/at.ed.4432201097>

CAPÍTULO 8..... 90

CHALLENGES IN INSECT PEST MANAGEMENT IN SUGARCANE CROP


Aimée Regali Selegim
Sergio Antônio de Bortoli
Dagmara Gomes Ramalho






 <https://doi.org/10.22533/at.ed.4432201098>

CAPÍTULO 9..... 97

SELECTIVITY OF INSECTICIDES AND BIOINSECTICIDES TO COMMERCIALY USED PARASITOIDS OF *DIATRAEA SACCHARALIS* ON SUGARCANE

Érica Ayumi Taguti
Gabriel Gonçalves Monteiro
Ivana Lemos Souza
Nilza Maria Martinelli

 <https://doi.org/10.22533/at.ed.4432201099>

CAPÍTULO 10	109
INTEGRATED MANAGEMENT STRATEGIES FOR KEY PESTS OF COFFEE CROP	
Bruno Henrique Sardinha de Souza	
 https://doi.org/10.22533/at.ed.44322010910	
CAPÍTULO 11	123
CHALLENGES OF DIGITAL AGRICULTURE IN PEST MANAGEMENT	
David Luciano Rosalen	
 https://doi.org/10.22533/at.ed.44322010911	
CAPÍTULO 12	134
USE OF REMOTE SENSING TO IDENTIFY AND MANAGE NEMATODES IN SOYBEAN CROPS	
Gabriela Lara Leite Alcalde	
Edicleide Macedo da Silva	
Morgana Baptista Gimenes	
Lorena Tozi Bombonato	
Pedro Henrique Vasques Bocalini	
Pedro Luiz Martins Soares	
 https://doi.org/10.22533/at.ed.44322010912	
CAPÍTULO 13	147
ENDOPHYTIC ENTOMOPATHOGENIC MICROORGANISMS IN PEST MANAGEMENT	
Lana Leticia Barbosa de Carvalho	
Fabiana Santana Machado	
Ricardo Antônio Polanczyk	
 https://doi.org/10.22533/at.ed.44322010913	
CAPÍTULO 14	156
<i>BACILLUS THURINGIENSIS</i> CRY PESTICIDAL PROTEINS SUBLETHAL EFFECTS ON TARGET LEPIDOPTERA AND THEIR IMPACT ON THE AGROECOSYSTEM	
Amanda Cristiane Queiroz Motta	
Nayma Pinto Dias	
Ricardo Antonio Polanczyk	
 https://doi.org/10.22533/at.ed.44322010914	
SOBRE OS AUTORES	167

IMPLEMENTATION CHALLENGES OF INTEGRATED PEST MANAGEMENT PROGRAMS IN AGRICULTURAL SYSTEMS

Marcelo Coutinho Picanço

Mayara Moledo Picanço

Ricardo Siqueira da Silva

1 | INTRODUCTION

The agricultural sector is vital to the Brazilian economy due to income, jobs, raw materials, energy, fibers, and food production. The success of these production systems is related to obtaining high yields and carrying out proper and efficient management (Kureski; Moreira & Veiga, 2020; EMBRAPA, 2018). Phytosanitary problems are among the main factors that limit the achievement of high yields in these production systems. On average, these problems cause losses of about 30% in plant yield, and in extreme situations, these losses can reach up to 100% (Cerdeira et al., 2017; Picanço et al., 2007). Integrated pest management programs are the most efficient and sustainable way of phytosanitary management (Pedigo; Rice & Krell, 2021; Picanço et al., 2014). Thus, this book chapter will discuss the components, current scenario, obstacles, and innovations in integrated pest management programs.

2 | COMPONENTS OF INTEGRATED PEST MANAGEMENT PROGRAMS

Integrated pest management programs have three components: diagnosis (or assessment of agroecosystems), decision-making systems, and control methods (Pedigo; Rice & Krell, 2021; Picanço et al., 2014). The diagnosis identifies the pests, the factors favorable to their attack, and the critical control points. Identifying pests is essential for understanding their bioecology, appropriate decision-making systems, and control methods. Knowing the factors favorable to pests makes it possible to predict the risks of their occurrence in different regions and times of the year, plan decision-making, and use control methods (Pedigo; Rice & Krell, 2021; Bacci et al., 2019; Picanço et al., 2014). The main factors affecting pest attacks are climatic elements, natural enemies, pest biology, host plant, control methods, environment, and planting system. These factors affect the migration, colonization, dispersion, development, growth, mortality, survival, reproduction, and behavior of pests (Bacci et al., 2019; Felicio et al., 2019; Picanço et al., 2014). Critical control points are related to spatio-temporal distribution and pests' morphological and behavioral characteristics. These points indicate when, where and what details should be considered in pest control

(Felicio et al., 2019; Picanço et al., 2014).

Decision-making systems are composed of sampling plans and a decision-making index. A sampling plan is the detailed planning of how and when it will be evaluated plants in the field. In these plans, the densities of pests and natural enemies are determined. These determinations are used in pest control decision-making to prevent pests from causing economic damage. Sampling performed before and after applying control methods also allows the efficient evaluation of the control methods used (Pedigo; Rice & Krell, 2021; Picanço et al., 2014; Bacci et al., 2007).

Sampling plans can be conventional and sequential. Conventional plans are considered standard, have a fixed number of samples per field, are more straightforward, and in them the decision-making has two stages. The first step is carried out in the field, and the samples are evaluated in it. The second stage is in an office where calculations are made and the pest control decision is made. The sequential plans are validated by the conventional plans, and the number of samples per field is variable (it is usually 50 to 90% lower than the conventional one). The sequential plan is more complex, executed in a single step in the field when the samples are evaluated and decisions are made (Arcanjo et al., 2021; Bacci et al., 2007). The decision-making indices of management programs determine whether the pest density is low or high. When this density is equal to or greater than the decision-making index, the pest population is high, and control must be carried out. When this density is lower than the decision-making index, the population is low, and control should not be carried out. The two main decision-making indices of integrated pest management programs are the economic injury level and the economic threshold (Arcanjo et al., 2021; Bacci et al., 2007; Higley & Pedigo, 1996).

Control methods can be divided into two groups: preventive and curative. Methods for preventive use are cultural control (or manipulation of the growing environment), plant resistance, and conservative biological control. The methods curative used are chemical control, augmentative biological control, behavioral control, and genetic control. Methods should be selected using technical, economic, ecotoxicological, and social criteria. According to the technical criteria, methods allowed by legislation and which are efficient must be used. By economic criterion, control methods must provide high crop yields and reduce costs per unit produced. According to the ecotoxicological criterion, the methods used must enable the preservation of the environment and people's health. According to social criteria, the methods used must be suitable for the planting system, farmer, and consumer (Pedigo; Rice & Krell, 2021; Araújo et al., 2017; Picanço et al., 2014).

3 | CURRENT SCENARIO OF THE AGRICULTURAL SECTOR AND PEST CONTROL IN BRAZIL

Currently, Brazil is the second-largest food exporter in the world. Agricultural and forestry products are the main items of our exports, and this sector is an excellent generator of jobs and income in the country. However, until the 1960s, Brazil was a food importer (EMBRAPA, 2018). Given this favorable current scenario, a question arises: what factors contributed to this positive change? Between these decades, changes in the public and private sectors led to these advances. Among these changes are expanding the Brazilian university system, graduate courses, state research companies, Embrapa, public and private extension services, private companies, agronomic prescriptions, no-tillage, expansion of the agricultural frontier, the program to collect empty pesticide containers, patenting and genetically modified varieties.

In pest, disease, and weed control, the global pesticide market moved US\$84.5 billion in 2019 and is expected to reach US\$130.7 billion in 2023. Brazil is the world's largest consumer of pesticides, and in 2021 this market moved 13.3 billion dollars. Among the three main groups of pesticides (fungicides, herbicides, and insecticides), the most commercialized (in weight or volume) are herbicides. However, due to their unit value in most years, insecticides are generally the ones with the highest market value. Sales of natural products represent about 6% of the pesticide market. In Brazil, in recent years, the market for natural products to control pests, diseases, and weeds has expanded by more than 70%. At the moment, more than 170 natural products are registered in Brazil to control pests, diseases, and weeds (MAPA, 2022; Researchandmarkets, 2022). In 2021, the global seed market was 62 billion dollars and was expected to reach 86.8 billion dollars in 2026, with a large part of these seeds being pest-resistant varieties (Marketsandmarkets, 2021).

4 | OBSTACLES TO THE IMPLEMENTATION OF INTEGRATED PEST MANAGEMENT PROGRAMS

The failure of integrated pest management programs is due to failures in research and the non-adoption of these programs by farmers. The research failures are due to the topics addressed not being relevant or due to the conduct of the studies having been carried out improperly (Peshin, 2013; Coutts & Christiansen, 2003). These researches should address diagnosis, decision-making, and control methods, as these are the components of integrated pest management programs. These studies must represent the crops where they will be used, and they must also consider the users and systems where they will be implemented. In selecting the components of these programs, technical, economic, ecotoxicological, and social criteria must be adopted (Picanço et al., 2022; Pedigo; Rice &

Krell, 2021; Picanço et al., 2014). In order to carry out these studies, it is important to have adequate infrastructure, a trained team, and resources. These surveys are usually carried out jointly by the public and private bodies. Another critical factor is the scientific training of the team responsible for these studies. This training is carried out by the Scientific Initiation programs and the Postgraduate Courses.

The adoption of integrated pest management programs by farmers depends on carrying out adequate technology transfer. The critical points for the success of the technology transfer process of the integrated pest management programs are efficient communication, simplicity of the process, economic part as a key point of the studies, actions to encourage technology transfer and extension, opinion-makers as critical customers, promoting quality over quantity and increasing interaction between producers and the community (Peshin, 2013; Coutts & Christiansen, 2003).

Another important aspect of technology adoption is that people are more likely to adopt innovations associated with products than processes. Thus, the procedures to be adopted must be related to products to enable greater adoption of technologies generated by farmers (Peshin, 2013). In this context, professionals in the resale of agricultural products in Brazil play a significant role in adopting technologies by farmers. This happens because these professionals are in daily contact with the farmers, and they have credibility with this public.

5 | INNOVATIONS IN INTEGRATED PEST MANAGEMENT PROGRAMS

Currently, the most demanding and enlightened consumers have significant influence over the technologies used in the production process. This influence can go beyond country borders. This happens when these consumers influence the selection of technologies to be adopted to produce products imported by their countries (Burnier; Spers & Barcellos, 2021; Basso et al., 2018; Picanço et al., 2016). In the agricultural sector, this influence has resulted in the production process requirements for certification. This certification establishes norms for using technical and ecotoxicological criteria to preserve the environment and human health and comply with local and international legislation. These production systems require the use of integrated pest management programs. Examples of this influence are the certification processes of planted forests, production of animal products, coffee, and fruit plantations in Brazil. In addition, the banning of organochlorine insecticides and organophosphate insecticides in various parts of the planet also influences these consumers (Burnier; Spers & Barcellos, 2021; Basso et al., 2018; Picanço et al., 2016; Edwards & Laurance, 2012).

In the coming years, there will be innovations in all components of integrated pest management programs. In these researches, new tools will be used that will help develop these studies. In the diagnosis, new problems with pests will be detected. This will occur due to climate change on the planet, changes in the production system, and biological invasions. With the increase in air temperature and the dry period of the year, the pests that live in the canopy of plants will increase their populations, especially the leaf-sucking and leaf-mining pests. With the increase in international trade and migration of people, new pests will be introduced in countries. Changes in production systems with the intensification of plantations in time and space, use of inputs, and the increase in crop yields will be favorable to having greater problems with pests (Chakravarthy, 2020; Chen et al., 2020; Gao & Reitz, 2017; Picanço et al., 2016).

Innovations in decision-making will occur both in the sampling plans and the adopted indices. In the samplings, sensors with artificial intelligence technology will evaluate the pest populations in the fields. Expert systems will make faster, more accurate, and more cost-effective control decisions using management zones. Innovations in control methods will include efficient products suitable for the user and the production system with less environmental impact. These products will have a higher unit cost, but they will have a lower cost per unit produced in the crops (Shah & Razaq, 2021; Chakravarthy, 2020; Chen et al., 2020; Picanço et al., 2016).

Another critical point in the innovations of integrated pest management programs will be the teaching and extension activities in this area of knowledge. It is vital to carry out remote and face-to-face teaching activities in high school, undergraduate, and graduate technical courses. In addition, it is also essential to carry out extension activities with rural workers, farmers, and technicians. We thank the National Council for Scientific and Technological Development (CNPq), the Brazilian Federal Agency for the Support and Evaluation of Graduate Education (CAPES) Finance Code 001, and the Minas Gerais State Foundation for Research Assistance (FAPEMIG) for the financial support of the activities that produced the knowledge contained in this book chapter.

REFERENCES

Araújo, T.A. et al. Toxicity and residual effects of insecticides on *Ascia monuste* and predator *Solenopsis saevissima*. **Pest Management Science**, v.73, p.2259-2266, 2017. 10.1002/ps.4603

Araújo, L.P. et al. Decision-making systems for management of the invasive pest *Neoleucinodes elegantalis* (Guenée) (Lepidoptera: Crambidae) in commercial tomato crops according to insecticide spray method and plant stage. **Crop Protection**, v.140, p.e105408, 2021. 10.1016/j.cropro.2020.105408

- Bacci, L. et al. Sistemas de tomada de decisão de controle dos principais grupos de ácaros e insetos-praga em hortaliças no Brasil. In: Zambolim, L. et al. (Eds.). **Manejo integrado de doenças e pragas - Hortaliças**. Viçosa: UFV-DFP, 2007. p.423-462.
- Bacci, L. et al. Seasonal variation in natural mortality factors of *Tuta absoluta* (Lepidoptera: Gelechiidae) in open-field tomato cultivation. **Journal of Applied Entomology**, Berlin, v.143, p.21-33, 2019. 10.1111/jen.12567
- Basso, V.M. et al. FSC forest management certification in the Americas. **International Forestry Review**, v.20, p.31-42, 2018. 10.1505/146554818822824219
- Burnier, P.C.; Spers, E.E.; Barcellos, M.D. Role of sustainability attributes and occasion matters in determining consumers' beef choice. **Food Quality and Preference**, v.88, p.e104075, 2021. 10.1016/j.foodqual.2020.104075
- Cerda, R. et al. Primary and secondary yield losses caused by pests and diseases: Assessment and modeling in coffee. **PLoS One**, v.12, p.e0169133, 2017. 10.1371/journal.pone.0169133
- Chakravarthy, A. K. **Innovative pest management approaches for the 21st century**: Harnessing automated unmanned technologies. Singapore: Springer, 2020. 519p.
- Chen, C.J. et al. An AIoT based smart agricultural system for pests detection. **IEEE Access**, v.8, p.180750-180761, 2020.
- Coutts, J.; Christiansen, I. **Changes in attitudes to integrated pest management in the Australian cotton industry**: 1997-2001 and attitudes to area wide management. Narrabri: Cotton CRC, 2003. 32p.
- Edwards, D.P.; Laurance, S.G. Green labelling, sustainability and the expansion of tropical agriculture: critical issues for certification schemes. **Biological Conservation**, v.151, p.60-64, 2012. 10.1016/j.biocon.2012.01.017
- EMBRAPA. **Visão 2030**: o futuro da agricultura brasileira. Brasília: Embrapa, 2018. 212p.
- Felicio, T.N.P. et al. Surrounding vegetation, climatic elements, and predators affect the spatial dynamics of *Bemisia tabaci* (Hemiptera: Aleyrodidae) in commercial melon fields. **Journal of Economic Entomology**, v.112, p.2774-2781, 2019. 10.1093/jee/toz181
- Gao, Y.; Reitz, S.R. Emerging themes in our understanding of species displacements. **Annual Review of Entomology**, v.62, p.165-183, 2017. 10.1146/annurev-ento-031616-035425
- Higley, L.G.; Pedigo, L.P. **Economic thresholds for integrated pest management**. Lincoln: UNL, 1996. 327p.
- Kureski, R. et al. Agribusiness participation in the economic structure of a Brazilian region: analysis of GDP and indirect taxes. **Revista de Economia e Sociologia Rural**, v.58, p.e207669, 2020.
- MAPA. **AGROFIT**: Sistemas de agrotóxicos fitossanitários. Brasília: MAPA, 2022. Disponível em http://agrofit.agricultura.gov.br/agrofit_cons/principal_agrofit_cons. Acesso em 24/04/2022.

Marketsandmarkets. **Seeds market by type**. Northbrook: Marketsandmarkets, 2021. 343p.

Pedigo, L.P.; Rice, M.E.; Krell, R.K. **Entomology and pest management**. 7 Ed. Long Grove: Waveland, 2021. 584p.

Peshin, R. Farmers' adoptability of integrated pest management of cotton revealed by a new methodology. **Agronomy for Sustainable Development**, v.33, p.563-572, 2013. 10.1007/s13593-012-0127-4

Picanço, M.C. et al. Effect of integrated pest management practices on tomato production and conservation of natural enemies. **Agricultural and Forest Entomology**, v.9, p.327-335, 2007. 10.1111/j.1461-9563.2007.00346.x

Picanço, M.C. et al. Manejo integrado de pragas. In: Zambolim, L.; Silva, A.A.; Picanço, M.C. (Eds.). **O que Engenheiros Agrônomos devem saber para orientar o uso de produtos fitossanitários**. Viçosa: UFV-DFP, 2014. p.389-436.

Picanço, M.C.; Lopes, M.C.; Silva, G.A. **Tópicos de manejo integrado de pragas I**. Viçosa: UFV-DDE, 2022. 338p.

Picanço, M.C. et al. Situação atual e inovações nos programas de manejo integrado de pragas. In: SIMPÓSIO BRASILEIRO DE AGROPECUÁRIA SUSTENTÁVEL, 7, 2016, Sinop. **Anais ... Sinop**: UFMT, 2016. p.91-104.

Researchandmarkets. **Agrochemicals market**. Dublin: Research and Market, 2022. 251p.

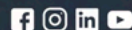
Shah, F.M.; Razaq M. From agriculture to sustainable agriculture: Prospects for improving pest management in industrial revolution 4.0. In: Hussain, C.M.; Di Sia, P. (Eds.). **Handbook of smart materials, technologies, and devices**. Cham: Springer, 2021. 18p.

LALLEMAND

Microbial by nature

BIOFUNGICIDAS
BIONEMATÓCIDAS
BIOINSETICIDAS
BIOINOCULANTES

agricultura RESPONSÁVEL MANEJO BIOLÓGICO



@lallemandplantcarebrasil
www.lallemandplantcare.com



ACCESSE O SITE LALLEMAND

+ DE

86

ANOS DE HISTÓRIA.

7 PLANTAS
INDUSTRIAIS
NO MUNDO,
4 DO AGRO.

1Bi

É A EXPECTATIVA DE
FATURAMENTO EM
2022 NO AGRO.

NO 3º ANO
DA COMPANHIA
NO AGRO, ESTAMOS
ENTRE AS

5 MAIORES
EMPRESAS DO
SEGMENTO.

AGRO.NITRO.COM.BR



OMBRO A OMBRO COM VOCÊ,
ENTREGANDO TECNOLOGIAS QUE AUMENTAM A
RENTABILIDADE DA LAVOURA DO PRODUTOR RURAL.

 **nitro**

A ESCOLHA MAIS SIMPLES PARA SUA PRODUTIVIDADE EVOLUIR



O Sistema Enlist® é a maneira **mais fácil** de manter o controle da sua operação para **maximizar o potencial produtivo** por meio de três pilares:

BIOTECNOLOGIAS

Conkesta E3
SOJA

Enlist E3
SOJA

HERBICIDAS

Enlist Duo
COLEX-D[®]
HERBICIDA

Enlist
COLEX-D[®]
HERBICIDA

GENÉTICA DE ALTA PERFORMANCE

Com variedades altamente produtivas dos principais parceiros



Enlist Certo

Boas Práticas Agrícolas

MAIS FACILIDADE PARA ALTA PRODUTIVIDADE

MAIOR CONTROLE

Redução no potencial de deriva e ultrabaixa volatilidade na aplicação, além da proteção contra lagartas.

CONVENIÊNCIA

Redução de odor, proporcionando comodidade aos aplicadores e comunidades vizinhas.

DIVERSIDADE

Sementes tolerantes às herbicidas Enlist® Colex-D[®] (nova 2,4-D sol colina), glifosato e glifosinato.

FLEXIBILIDADE

Compatível com diversos sais de glifosato, de acordo com a bula.





Os eventos de soja transgênica contidos nas variedades de sojas Enlist E3® e Conkesta E3® são desenvolvidos e pertencem conjuntamente à Corteva Agriscience e à M.S. Technologies L.L.C. Enlist® Colex-D[®] deve ser usado em dessecação da soja, em pré-plantio (aplique/plante) e em pós-emergência das sojas Enlist E3® e Conkesta E3®.

ATENÇÃO PRODUTO PERIGOSO À SAÚDE HUMANA, ANIMAL E AO MEIO AMBIENTE; USO AGRÍCOLA; VENDA SOB RECEITUÁRIO AGRÔNOMICO; CONSULTE SEMPRE UM AGRÔNOMO; INFORME-SE E REALIZE O MANEJO INTEGRADO DE PRAGAS; DESCARTE CORRETAMENTE AS EMBALAGENS E OS RESTOS DOS PRODUTOS; LEIA ATENTAMENTE E SIGA AS INSTRUÇÕES CONTIDAS NO RÓTULO, NA BULA E NA RECEITA; E UTILIZE OS EQUIPAMENTOS DE PROTEÇÃO INDIVIDUAL.

TOPICS IN

AGRICULTURAL ENTOMOLOGY

XIII

 www.atenaeditora.com.br
 contato@atenaeditora.com.br
 [@atenaeditora](https://www.instagram.com/atenaeditora)
 www.facebook.com/atenaeditora.com.br



TOPICS IN

AGRICULTURAL ENTOMOLOGY

XIII

-  www.atenaeditora.com.br
-  contato@atenaeditora.com.br
-  [@atenaeditora](https://www.instagram.com/atenaeditora)
-  www.facebook.com/atenaeditora.com.br

