Topics in Agricultural Entomology XIII

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João Rafael Silva Soares
Matheus Cardoso de Castro
Sandy Sousa Fonsêca
Vinicius Ferraz Nascimento
Ricardo Antonio Polanczyk

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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 3

IMPLEMENTATION CHALLENGES OF INTEGRATED PEST MANAGEMENT PROGRAMS IN AGRICULTURAL SYSTEMS

Marcelo Coutinho Picanço

Mayara Moledo Picanço

Ricardo Siqueira da Silva

1 I 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% (Cerda 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 I 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 I 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 I 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 I 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.

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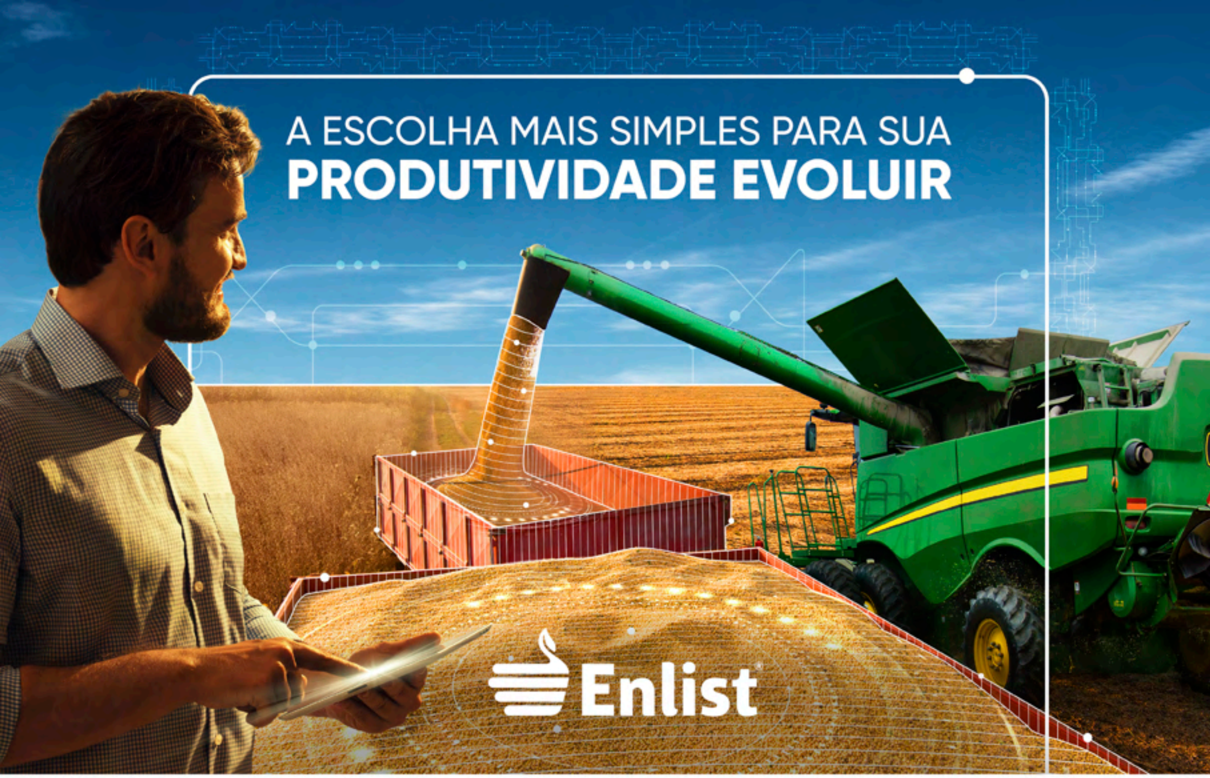

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