# TRENDS IN IPM: A COMMENTARY FROM AN IRAC PERSPECTIVE

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Insecticide Resistance Action Committee

## Summary:

This short paper outlines the IRAC International position on trends in Integrated Pest Management (IPM) in relation to insect resistance management. Though IPM is not IRAC International's primary expertise, IRAC will, where appropriate, seek to enable the dissemination of information on IPM options developed by research institutions, academia, or government agencies for certain crop-pest situations through our outreach channels. IRAC International encourages IPM in the context of resistance management (RM).

## Resistance Management

IRAC International describes resistance to insecticides, insecticidal traits in genetically modified crops (GMOs), acaricides or nematicides as a 'heritable change in the sensitivity of a pest population that is reflected in the repeated failure of a product to achieve the expected level of control when used according to the label recommendation for that pest species".

Resistance can be managed by using strategies, that extend the number of generations that a given pest can be controlled with tactics other than the same pesticide according to label recommendations.

IRAC promotes resistance management (RM) strategies through the production and distribution of technical information. Our focus and expertise lie in the classification of Modes of Action (MoA) of insecticides, insecticidal traits, acaricides and nematicides and the development of resistance management strategies based on the optimal use of products with different MoAs in agriculture and public health (Sparks et al., 2021). IRAC also develops strategies for resistance management in GMOs.

## Integrated Pest Management, as a holistic approach

In addition, IRAC fully supports integrated pest management (IPM) as a holistic and sustainable approach towards controlling insect pests as recently described by Dara (2019). Our definition of IPM is the integration of any economically viable method for managing insect pest populations in a given pest-cropping system situation, including the use of insecticides (Fig.1). Indeed, insecticide resistance in arthropods is one of the key motivators for the continuous development of new IPM strategies (Umina *et al.*, 2019). Though IPM is not IRAC's primary expertise, IRAC will, where appropriate, seek to enable the dissemination of information on IPM options developed by research institutions, academia or government agencies for certain crop-pest situations through our outreach channels.

IPM is an approach that has been used in crop protection for several decades (Dara**,** 2019).

- IPM provides environmentally sensitive and effective strategies for pest control
- IPM is based on science, combining biological, physical, cultural and chemical tools for pest control
- IPM can follow both preventative and curative strategies based upon action thresholds
- IPM includes the use of synthetic pesticides or genetically modified crops (GMO) where appropriate
- When synthetic pesticides or GMOs are integrated into IPM strategies, the risk for pests to develop resistance can be significantly reduced
- Accordingly, IRAC International encourages IPM in the context of resistance management (RM)

IPM strategies may employ a large number of tactics to reduce pest pressure.  These can include cultural and agronomic practices such as crop rotations or removal of crop residues and alternative host plants. Biological control using predators or parasitoids is now well established in controlled environments, such as greenhouse grown crops. Sterile male technology is used in vector control. Pheromone technology (e.g. “mating disruption”) is commonly employed in specialty crops such as viticulture, orchards or greenhouses, and is now being explored in field crop situations.  The conservation of natural enemies is a key element in IPM programs and in this context the introduction of BT crops played an important role. In the US, BT cotton crops served as a model, where the concept of natural enemy conservation was conceived and implemented, altering the pest status of whiteflies in the cotton growing system of Arizona (Naranjo & Ellsworth, 2009). Conventional plant breeding for virus tolerance and new gene editing techniques such as CRISPR-Cas can be part of such an approach as well. In addition, highly targeted insecticides are becoming available based on RNA interference (RNAi).

In Public Health, 'Integrated Vector Control' (IVC) adopts a holistic, systems approach to reducing the burden of vector-borne disease. Long-lasting insecticide-treated bed nets (LLIN) and indoor residual wall spraying (IRS) are often the cornerstone of malaria vector control, but they are not the only methods to reduce interactions between Anopheles mosquitoes and people. An IVC approach encourages the use of additional insecticide-based methods, such as mosquito larvicides, space sprays, and spatial repellents. It also promotes non-insecticidal activities like environmental modification to reduce larval breeding sites, housing improvements to minimize mosquito entry, personal repellents, and enhanced water services (Tongyan & Rui-De, 2024).

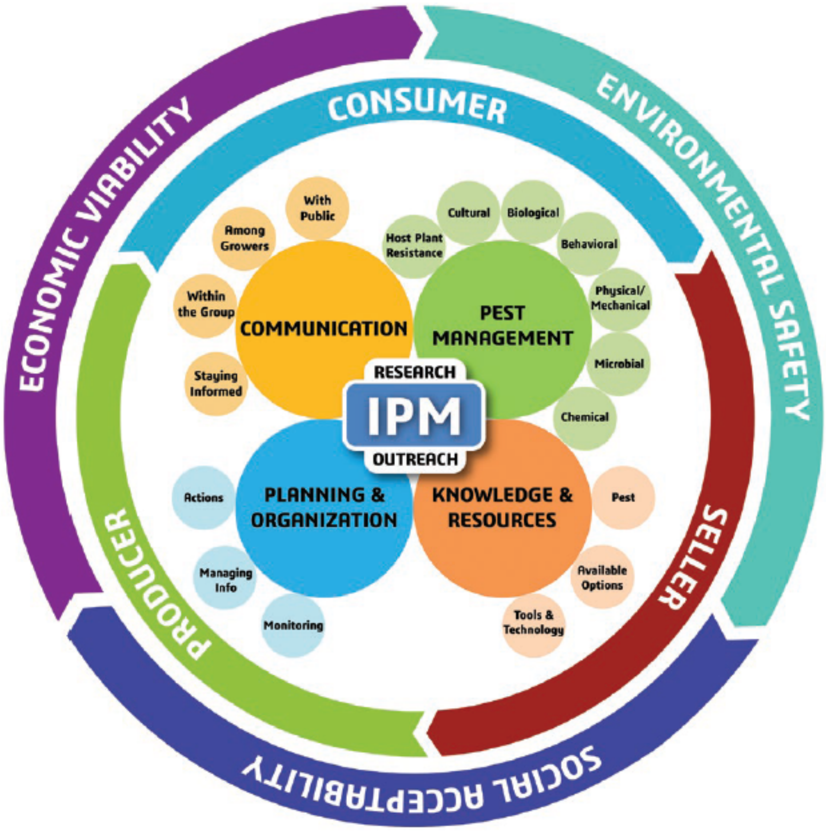


Fig. 1. New IPM paradigm with its various components and influencing factors for economically viable, socially acceptable, and environmentally safe pest management (with permission of S. Dara)

## Leveraging an understanding of socioeconomics with communication and training

Socioeconomics is a social science and a branch of economics that focuses on the relationship between social behavior and economics. Well-developed socioeconomic plans in agricultural sectors can be deployed through communication and training programs to educate farmers and promote best practices to avoid actions that increase the risk of development of insecticide resistance. The development and implementation of such frameworks is not simple, however. In the US for example, as the demand has increased for IPM specialists, institutional support has declined through the loss of extension-related positions in land-grant universities. The erosion of structures that enable knowledge transfer to the field is one of the most serious threats to effective IPM program implementation (Castle *et al.*, 2009). As mentioned above, the European Commission sees IPM as the main tool towards pesticide reduction. But so far, in arable crops, effective IPM systems have neither been developed or implemented. Despite tremendous research and efforts to develop practical IPM strategies, area-wide implementation of integrated pest management had previously been considered unrealistic in arable farming for economic and advisory reasons (Freier & Burth, 2006).

IPM schemes can only be useful and contribute to changes in actual agricultural practices if socioeconomic factors are well managed. These factors include concerns about the cost, the feasibility from a technical perspective and a thorough education on IPM tactics along with its implications in crop protection (Lane *et al.,* 2023). One of the few examples of widespread farmer-level adoption of an IPM program in field crops was for whitefly control in Arizona, USA. The initiative was heavily supported by governmental officials and academia and resulted in great agroecological and financial benefits for the agricultural industry (Naranjo and Ellsworth, 2009). Another success story of IPM for field crops comes from the north-eastern grain farming system in Australia (Brier *et al.*, 2008, Umina *et al.,* 2019). Examples for successful IPM in greenhouse crops are common (Glass & Gonzalez, 2012, Pizzol *et al.,* 2010, Pilkington *et al.,* 2010). Further information on stakeholder involvement and areawide community action is described in IRAC's Advanced Module: Organizing an Integrated Resistance Management Campaign: https://irac-online.org/documents/advanced-training-module-on-irm/?ext=pdf. IRAC International hopes that providing more information on IPM on the IRAC website can help stakeholders to make a leap from traditional resistance management to an integrated approach involving IPM.

## The declining number of available insecticidal modes of actions and mandatory dose reductions are a challenge for resistance management, even in IPM systems

In many regions, the implementation of IPM programs is supported by governmental institutions. One of the reasons is that the declining number of registered insecticidal MoA's for certain crop-pest systems had reached such a low level that rotation of effective MoAs had become increasingly difficult or impossible. An example of this is the control of cabbage stem flea beetle, *Psylliodes chrysocephala*, in oilseed rape in the European Union (EU) (Ortega-Ramos *et al.,* 2022). Recent moves towards a reduction of pesticide use might in theory reduce the selection of resistance, but as already pointed out in the 'Declaration of Ljubljana' in 2008, this legislative change might instead increase the risk of resistance evolution due to a diminished diversity of chemical options for farmers used to MoA rotation schemes in their pest control programs (Bielza *et al.,* 2008). With potentially only a few, or in the worst case only a single MoA available, the options become very limited for minimizing selection pressure to avoid resistance development. Another reason for the non-availability of rotation partners for efficient resistance management can be the reduced number of efficacious MoA for a particular pest, such as thrips in some cropping systems (Bielza, 2008). In other regions higher prices for insecticides with alternative MoAs (Mukanga *et al.*, 2024) or secondary standards imposed by supermarkets (IRAC Spain, 2012) regarding the number of different residues on their produce, may prevent farmers from rotating MoA's for resistance management. For many but not all crop-pest situations, IPM strategies can help to manage the gap. A reduction in the availability of MoAs for resistance management could make IPM strategies more attractive, however the time to develop or ability to implement these other strategies remains a challenge.

Mandatory pesticide dose reductions as sometimes required by EU legislation, are another factor threatening resistance management. Again, under such circumstances, IPM might be the best approach available to delay the evolution of resistance (Munitz-Junior *et al.*, 2023)

## Factors impacting the implementation of IPM

In Almeria Spain, the lack of registered efficacious pesticides available in the market following the introduction of new EU legislation (EC, No 1107/2009), is already one of the drivers for change to IPM (Glass & Gonzalez, 2012). This has made the change to augmentative biological control necessary with protected greenhouse crops, such as tomato and peppers. Since 2007, there has been a much greater uptake of IPM in Almería, expanding to a wide range of crops. This has also allowed greater use of bumblebees as pollinators, following reduced insecticide use (Glass & Gonzalez, 2012). At the same time, after the accidental introduction in Spain of an invasive pest, the tomato leafminer, *Tuta absoluta*, in 2006, increased insecticide use, and insecticide resistance caused changes in arthropod community patterns, leading to additional pest outbreaks, putting existing IPM strategies under risk (Guedes *et al.*, 2019).

The successful implementation of IPM strategies can be difficult or even fail for many reasons. Lack of farmer knowledge, user preferences or risk aversion are reasons often mentioned when discussing the slow adoption of IPM. Or, as for example in the EU, IPM principles it promotes, do not correspond to an explicit and orderly description of practices, or phytosanitary strategies (Deguine, 2021).

One of the actions IRAC International is taking is to provide more specific information on IPM on the pest pages of the IRAC website.

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