IPM toolkit preservation

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Preserving biodiversity and natural enemies is an IPM tactic to help keep pest populations below economic thresholds. Shown here are lacewing larva eating soybean aphids. Photo by David Cappaert, Bugwood.org.

Integrated pest management (IPM) is a holistic approach that considers all farming practices and control tactics to discourage the development of economically damaging pest populations with a focus on preventing and managing pest populations as opposed to single interventions to eliminate pests once a problem has occurred. The idea of the IPM toolkit analogy is to keep as many tools in the toolbox as possible to manage agricultural pests; the more tools available, the better chance of providing a solution to a given pest threat. Preserving these tools is critically important to IPM. This article is the second in the three-part series in *Crops & Soils* magazine. It is part of an American Society of Agronomy training series sponsored by the Kellogg Company.

Integrated pest management (IPM) is evolving in support of contemporary sustainable agriculture initiatives. The principles of IPM were developed in the 1950s and 1960s, and the terminology and concept of IPM became recognized through the 1970s; since then, IPM has been part of pest management discussions, but in the past few years, IPM concepts have taken on a broader context and been linked to all aspects of crop protection. In the early days, IPM was often associated with insect control and an integrated management plan for specific pests to help reduce the reliance on insecticides; the IPM approach is now being discussed across farm management systems. The overall focus on sustainable agriculture has expanded interest in IPM to maintain the pest management tools we have available and to support biodiversity and the environment.

Integrated pest management is a holistic approach that considers all farming practices and control tactics to discourage the development of economically damaging pest populations with a focus on preventing and managing pest populations as opposed to single interventions to eliminate pests once a problem has occurred. When intervention is required, chemical controls are an important part of IPM systems, with biologicals and cultural controls, implemented in a way that minimize risks to human health and the environment.

Through innovation in breeding, crop protection, fertility, and machinery, the agricultural industry has succeeded in feeding a growing population, but challenges are being recognized. The limits on land available for cultivation are being reached while at the same time, over-reliance on some crop protection tools has led to resistance or regulation that may limit future utility. There is increasing emphasis on sustainable practices and protecting biodiversity while maintaining yield gains and minimizing losses to pests. A more integrated overall approach is required to preserve important crop protection tools while maintaining production levels and reducing environmental impacts.

IPM Toolkit Analogy

The idea of the IPM toolkit analogy is to keep as many tools in the toolbox as possible to manage agricultural pests; the more tools available, the better chance of providing a solution to a given pest threat. Combining multiple management tactics that impact the same pest populations is the best way to maintain the effectiveness of those tactics.

Tillage can be an important tool in IPM systems, particularly for managing resistant weeds. Photo by Austin Pearce.

There are three basic components to IPM systems: prevention, monitoring, and intervention (see **https://bit.ly/3gpFTKx**). Prevention includes all tactics available to maintain pest populations below economic thresholds (e.g., crop rotation, variety selection, and preserving biodiversity and natural enemies, etc.). Monitoring involves scouting, measuring, forecasting, and modeling both pests and beneficials to understand when economic thresholds will be met and determine the appropriate intervention for pest management. Intervention is implementing cultural, biological, or chemical controls to manage pests below economically damaging levels.

Application practices are a critical part of an IPM strategy to preserve crop protection tools. Source: Shutterstock/stock image.

Integrated pest management is not an all or nothing proposition; rather, it is a continuum, and all growers are practicing some IPM principles. The level of integration depends on individual farms and crops, and while there is always room for improvement, a foundation of on-farm IPM practices exists to build from. For instance, growers are practicing pest identification, but there may be an opportunity to better understand pest life cycles or to improve the understanding of natural enemies and their life cycles. Growers are scouting and monitoring individual crops and pests, but new technologies and education offer opportunities for development. Understanding pest thresholds is key to IPM, and while the principles of economic thresholds do not change, there are variables like input costs and commodity prices that will impact thresholds and require continued attention. Evaluation is also part of IPM and something that growers are doing, keeping track of how practices are performing, experimenting with different management approaches, and understanding what works best on individual farms or crops. These are areas of IPM where there is little danger of losing tools, and new technologies promise to bring improvements and efficiencies.

Preservation of Tools

Interventions or controls are the other key components of IPM systems, and it is primarily in this area where there is the potential of losing tools. There are three basic types of controls: Biologicals, which includes natural enemies as well as biocontrols or biostimulants that are introduced by growers; chemical controls, which include synthetic or organic crop protection products; and cultural controls, which can include any number of tactics growers deploy to manage pests (e.g., rotations, genetics, plant populations, row spacings, tillage, physical barriers, etc.). Growers are generally utilizing controls across these categories, but increased diversification is important to preserve the controls available for IPM systems.

Benefits from practices supporting biodiversity, soil health, or resistance management like cover crops, reduced tillage, or diversified rotations compliment proper chemical applications to help mitigate risks around leaching or runoff. Photo by Keren Duerksen.

There are many examples of how tools might be lost. Regulatory pressure on some chemical tools may limit their use. As we reduce tillage to promote soil health, tillage is a tool that potentially becomes less available in some systems. Profitable rotational options might be limited by infrastructure or marketing opportunities or the need for new equipment. Resistance is perhaps the most familiar threat to the effectiveness of a growing number of crop protection tools. Agriculture is dealing with pest resistance on many fronts, including chemical controls, genetic traits, and even some cultural practices. The reality is that if a control tactic is repeatedly relied on to control a pest population, the genetic variability in that pest population will result in adaptation to that control tactic, making it less effective.

Herbicide resistance is an example that many growers are now experiencing. Herbicides have been one of the most important tools for production increases. They are effective and easy to use, which can lead to overreliance, and in many cases, resistance. Weed resistance is also a good example of how a more integrated approach can preserve the tools that are available. Use recommendations for full application rates and multiple modes of action are fundamental to resistance management across disciplines, but introducing other practices like tillage or cover crops have become more important to maintaining weed control. Growers are diversifying rotations to support weed management or experimenting with row spacing or planting rates to develop a more competitive stand. Topics like seed bank management are getting more attention, controlling weed escapes and evaluating weed seed destructors with harvest equipment. These practices can help reduce the reliance on herbicides and preserve the effectiveness of existing herbicide technologies. Herbicides are not only critical to maintain production practices, but are essential in the transition and implementation of sustainable agriculture initiatives including cover crops or reduced tillage for soil health. Diversified practices that support IPM also support resistance management and overall sustainable farm management plans.

Scouting for pests in soybean. Photo by Phil Needham.

A much different example of preserving tools is natural enemies. Insect predators and parasitoids can play an important role in keeping pest insects below threshold. Natural enemies may not control a pest outbreak once it occurs, but they are providing pest suppression that can delay or prevent pests from reaching an economic threshold, potentially reducing the number of applications required. Insect pressure is top of mind when economically significant outbreaks occur, but it should be recognized that natural enemies are often responsible when pest insects are not conspicuous or economically significant. Monitoring for both pests and beneficials should be considered as control decisions are made in terms of product selection and application timing to minimize the impact on beneficials. Habitat loss is the principal concern for biodiversity in most ecosystems. Natural areas, field margins, or wetlands are reservoirs for biodiversity and beneficials, which can be viewed as resources rather than unused land to be brought into production. There are programs now available that encourage multifunctional field margins and support overall biodiversity as well as pollinator health. Principles of IPM promoting beneficials support resistance management and reduced environmental impacts, helping to keep tools available to growers.

Application practices are a critical part of an IPM strategy to preserve crop protection tools. The intrinsic properties of a crop protection product are the foundation of performance, but equally important is the application; both in terms of efficacy and off-target or environmental impacts. Making good decisions about calibration, nozzles, spray timing, mixing order, water volumes, boom height, wind speed, and many other considerations all help to maximize efficacy. This can prevent the need for extra applications and reduce the risk of resistance development to maintain the effectiveness of chemical tools. Proper applications are also critical to avoid impacts to nontarget crops or natural areas and potential contamination of soil or water. Tank clean-out, waste disposal, and container management are equally important to minimizing environmental impacts and keeping chemical tools available to growers. Best management practices for applications also save time and money while reducing the risks of phytotoxicity or residues in crops, benefiting IPM and overall farm management.

Diversity of Control Options Enable the Best Management

Linking these best management practices as part of a holistic approach further strengthens the system. Benefits from practices supporting biodiversity, soil health, or resistance management like cover crops, reduced tillage, or diversified rotations compliment proper applications to help mitigate risks around leaching or runoff. Field margins that support biodiversity and pollinators are also mitigating drift risk. Principles of IPM and a diversity of control tactics provide support across sustainable management plans; the more tools available, the more resilient the management system.

Tactics and objectives are generally aligned across sustainability initiatives (biodiversity, regenerative ag, IPM, etc.); however, there are always exceptions. Tillage is an example. It is discouraged in regenerative agriculture systems that focus on minimizing soil disturbance to improve biodiversity, increase organic matter, and reduce erosion; however, tillage can be an important tool in IPM systems, particularly for managing resistant weeds. Another example is crop protection products being implemented based on experience and forecasting but before knowing the exact pest population (e.g., pre-emergent herbicides or seed treatments). This may not be fully aligned with all IPM threshold principles but may have sustainability benefits when weighed against the alternatives such as reactive pest control measures or crop loss. Environmental and sustainability considerations (e.g., resource efficiency, biodiversity, resistance management, carbon footprint, etc.) should be evaluated as control options are decided. There will be consequences for any control strategy, which will be unique to individual farms, reinforcing the importance of a diversity of control options for growers to enable the safest, most sustainable, and most effective management strategies.

Digital agriculture and rapid advancements in data management and crop imagery will also support IPM. Source: Adobe Stock/ Monopoly919.

While preserving tools is critically important to IPM, innovation will continue to support existing tools and deliver new technologies. Biologicals have been a foundation of IPM since its inception, and there are many examples of successes with predators and parasitoids or mating disruption tactics. These successes have often been in more intensively managed cropping systems, and introduced biologicals have not played a large role in broad-acre agriculture for various reasons. In recent years, there has been significant investment in biologicals research, which is resulting in more cost-effective and efficacious products. Improved biological tools, including microbials, pheromones, and other natural substances, will deliver increasingly effective solutions for biotic stresses (weeds, insects, nematodes, and diseases). Biostimulants that promote crop health are delivering new solutions for abiotic stress management, including climate stress, nutrient efficiency, and soil limitations; biostimulants are becoming better understood and implemented at scale.

Continued advancements in crop (and pest) genomics with developments in data collection and analytics support breeding technologies that promise to deliver improved genetic pest tolerance, faster and more efficiently. Digital agriculture and rapid advancements in data management and crop imagery will also support IPM. New tools are being developed for pest identification and real-time monitoring. Modeling and forecasting to predict pest infestations based on environmental conditions (temperature, humidity, and wind) and crop development will enable more precise and more effective timing for controls. Crop imagery with satellites or drones is enabling precision pest management, targeting specific areas rather than broadcasting treatments over entire crops—innovation that will bring benefits across all aspects of sustainable production.

Integrated pest management is fundamental to sustainable agriculture and is being practiced at some level on every farm. The agriculture sector is well positioned to support improved IPM approaches and diversified tactics that utilize and preserve existing tools. Innovation will also provide new tools to support IPM, which will bring opportunities across the value chain. While IPM is not a new concept, its principles are well positioned to support new opportunities in sustainable agriculture.

Take-Home Points

1. Over-reliance on the intervention element of pest management will result in the loss of tools for pest control. A balanced approach of prevention and monitoring with a diversity of pest control tactics supports keeping more control options available to farmers.

2. A more holistic approach to pest management is required, and this supports not only IPM, but overall sustainable farm management.
3. Chemical controls are essential tools for many IPM and sustainable agriculture initiatives. Practices that support maintaining efficacy and minimizing environmental impacts are helping to keep these tools available to growers.
4. Each farm is unique, so growers need as many control options as possible to enable tailored successful pest management strategies.
5. Innovation is essential to support improved success with integrated approaches, and IPM and sustainable agriculture must embrace new technologies.

More integrated pest management

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