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An Overview of Integrated Pest Management's (IPM) Eight Principles

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ABSTRACT: Pesticides allowed farmers to boost yields, simplify cropping methods, and avoid more complex crop protection measures. Overreliance on chemical control, on the other hand, has been linked to ecosystem pollution and negative health consequences. The development of insect resistance and the diminishing supply of active chemicals have put the future of agricultural production in jeopardy. As a result, farming methods that are less reliant on synthetic pesticides must be developed. As a result, the European Union mandates the use of eight Integrated Pest Management principles (P) that are compatible with long-term farm management. We offer a dynamic and adaptable approach to farmers, advisers, and researchers that accounts for the variety of farming circumstances and the complexity of agro ecosystems, and that may enhance cropping system resilience and our ability to adjust crop protection to local reality. We feel that (P1) the design of intrinsically resilient cropping systems employing a mix of agronomic levers is critical to prevention for each principle (P). (P2) The realities of local monitoring, warning, and forecasting systems must be dealt with. (P3) Cropping system variables may be included into the decision-making process to create longer-term plans. (P4) Synergies may be created by combining non-chemical techniques that are individually less effective than pesticides. (P5) The development of novel biological agents and goods, as well as the utilization of current databases, provide choices for choosing products that have the least effect on human health, the environment, and pest biological management. (P6) Pesticide reduction may be used in conjunction with other strategies. (P7) The best approach to discover long-term crop protection solutions is to address the underlying causes of pesticide resistance. In addition, (P8) including multi-season impacts and trade-offs into assessment criteria will aid in the development of long-term solutions.

KEYWORDS: Europe Pesticides, Integrated Pest Management, Resilient cropping system, Sustainable Agriculture, Sustainable Farming.

1. INTRODUCTION

Pesticide usage for crop protection is linked to negative consequences for the environment, human health, and the long-term effectiveness of pesticides [1]. With the introduction of synthetic pesticides, cropping systems may now be simplified and more complex crop protection methods can be avoided. However, this process jeopardizes the future of crop protection. Over-simplification of cropping systems, along with an over-reliance on chemical weed control, has resulted in widespread herbicide resistance, worsened by the continued and broad use of a few modes of action. Insects and diseases both exhibit the same behavior. Resistance is more likely to develop when the number of accessible active drugs decreases. According to the European Commission, more over 1000 active substances were approved in 2001, compared to little over 250 in 2009, and the trend continues to be lower [2]. According to a research by the European Crop Protection Association, there were 70 novel active compounds under development in 2000, but just 28 in 2012. IPM (Integrated Pest Management) is becoming more widely recognized as a viable solution to these issues.

Since the advent of integrated control, which is defined as applied pest management that combines and integrates biological and chemical control, IPM has gone a long way. Entomologists devised the idea in response to widespread broad-spectrum insecticide usage, insect epidemics caused by the eradication of natural enemies, and the development of pesticide resistance. IPM is currently used to safeguard plants in many areas. It has resurfaced as a focus of European policy, research, and extension initiatives aimed at mainstreaming it throughout the EU. This issue is addressed in the EU Framework Directive 2009/128/EC on the sustainable use of pesticides [3]. It offers a description of IPM that is mainly based on the UN Food and Agriculture Organization's definition, with the idea of pest control techniques replaced by plant protection methods and the concept of ecological justification added to that of economic justification.

These changes indicate a growing interest in learning about and engaging with ecological systems. Starting January 1, 2014, the EU Framework Directive requires all EU Member States to establish a National Action Plan to guarantee that a set of eight broad IPM principles are followed by all professional pesticide users. In addition to the Directive, Regulation 1107/2009/EC on the placement on the market of plant protection goods mandates that pesticides be used correctly, which includes adhering to general integrated pest management principles. Simply stated, the new EU pesticides package, which consists of two Directives and two Regulations, seeks to reduce risk throughout the use phase of pesticides and requires all pesticide users to practice IPM. IPM, on the other hand, is a multi-faceted strategy that involves a variety of disciplines and economic sectors. Producing unambiguous suggestions that are relevant to the variety of European agriculture is a tough task.

The authors of this article, examine the eight basic principles of IPM from the perspectives of research, farm advice services, and farmers. Our goal is to encourage IPM practitioners to accept the complexities that come with developing long-term crop protection plans. We provide reasons and examples for how IPM's site-specific, dynamic, systemic, and knowledge-intensive character may be considered and transformed into practical actions. In our opinion, long-term, strong, and well-adapted pesticide-reduction initiatives cannot be contained inside recipe-like suggestions. As a result, we don't offer a detailed how-to guide or checklist for each principle's application. Rather, we emphasize Principle 1 on prevention, which, together with the other seven principles, takes priority in theory but frequently requires the most significant adjustments to existing procedures. We don't concentrate on these crops since biological control, climatic management, and soilless options already contribute to a high degree of IPM for many covered horticultural and vegetable crops. Instead, we've decided to focus on examples from today's most difficult IPM application areas, such as arable crops.

IPM is a holistic company that emphasizes a systems-based approach. It achieves synergy by combining preventative measures from a variety of perspectives. It is based on agronomic, mechanical, physical, and biological principles, and it employs selective pesticide application in circumstances when other instruments are ineffective [4]. To guarantee the long-term viability of control measures, it is necessary to rely on a broad range of solutions. Otherwise, continuous use of a single method against a given pest—authors define "pests" as "any species, strain, or biotype of plant, animal, or pathogenic agent injurious to plants or plant products" as defined by the International Plant Protection Convention—induces pest populations to evolve, adapt, and overcome the control method, even if it is the most favorable solution at the time. Overreliance on a single technique may lead to a change in a pest community's composition toward species that are less sensitive to that method.

The faster the process is, the greater the selection pressure imposed by the control technique. IPM concepts apply to cropping systems across a broad geographical and temporal scale rather than individual crops whether it comes to research, extension, monitoring, assessment, or the development of recommendations. Many of the important levers for creating resilient agro ecosystems may be found at the cropping system level as well as at higher scales, such as area-wide IPM and landscape ecology. Taking a systems approach to the issue allows us to imagine less susceptible cropping systems, move away from curative management, and more completely implement Principle 1 on the prevention and suppression of hazardous species.

IPM manifests itself in a variety of ways that change across time and place. It is influenced by site-specific variables including regional cropping patterns, field size, the kind and availability of semi-natural habitats, the larger landscape, cultivation methods, insect pressure, R&D activities, training availability, farmer attitude, and economics. Farmers may develop along an IPM continuum ranging from no IPM to high or highly intense IPM [5]. Plant varieties, crop rotations, landscape features, and new technologies are all part of the continuum, which includes integrating optimized pesticide use with non-chemical strategies in current crop production systems as well as more radical redesigns of production systems involving plant varieties, crop rotations, landscape features, and new technologies.

The "Holy Grail" to contemplate is "ultimate IPM," a perfect—and possibly unattainable—situation in which the cropping system is so well-designed that no crop protection intervention is required once it is in place. Individual farmers, on the other hand, implement IPM via a multi-year process of gradual incorporation of new solutions. They may respond to changing pest threats, agricultural strategies, and incentives by gradually adapting. New methods altering dosage, sowing date, stand density, fertilizer application, usage of growth regulators, and rotations are adopted piecemeal over time, according to a survey of arable farmers. One modification leads to another, culminating in system-level alterations being fine-tuned.

2. DISCUSSION

This section discusses the eight principals (P) in details:

2.1. P1 - Prevention and Suppression:

The first basic guideline in any manufacturing system is that prevention is better than treatment [6]. The development of agricultural systems that are intrinsically less prone to suffer substantial economic losses owing to the presence of pests may be termed prevention. Suppression, defined as the decrease of pest occurrence or the intensity of their effect, is an important complement to prevention. This concept states that the goal is to prevent any one pest from becoming dominant or harmful in a cropping system, rather than to totally eradicate pests.

2.2. P2 - Monitoring:

Beyond prevention, shifting away from a pesticide-based approach requires continuous monitoring of hazardous species or the issuing of local warnings. Before deciding on pest management, all farmers would monitor pest numbers and utilize forecasting tools in an ideal world [7]. However,

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the present fact is that warning and forecasting systems for all crops are neither accessible nor cheap in all nations. Despite this, several nations have established effective support systems. A comprehensive monitoring system connected to the farm advice system in Denmark has helped the nation rank among the European Union's lowest pesticide users in arable crops. In Germany, a web-based forecasting tool that incorporates meteorological data into disease models aids regional agricultural decision-making.

2.3. P3 - Decision Based On Monitoring And Thresholds:

While sound intervention thresholds are essential in IPM, they aren't always appropriate, accessible, or adequate. Weed thresholds have yet to be determined in many instances. This is also true for infections, especially those that change their lifestyle from saprophytic to pathogenic in response to environmental events and climatic circumstances. Many IPM algorithms have previously focused on threshold-based choices. The usage of thresholds, as well as the notion of IPM, is ignored when decision-support systems are not in place or are not suitable. In such situations, it may be more appropriate to emphasize the significance of observation in general, good decision criteria, and the full set of IPM principles.

2.4. P4 - Non-Chemical Methods:

If non-chemical techniques offer acceptable pest management, giving priority to non-chemical ways over chemical ones seems to be a reasonable and simple concept. The problem is in determining what constitutes adequate pest management [8]. The authors believe that the highest level of control achieved by chemical measures is often not sustainable, creates new pest problems, and is not a proper standard against which single non-chemical tactics should be measured; instead, a satisfactory and sustainable level of pest management can be achieved through a broad IPM strategy that incorporates a variety of protection methods. If externalities are not taken into account, any alternative technique, such as a biopesticide, may perform with lower and slower biocidal power and seem more expensive than synthetic pesticides. Alternative approaches, on the other hand, should work together to create synergies that result in effective pest control. If pesticide steering taxes, which are being considered in many European nations, are implemented, their cost may become more appealing. Principle 8 provides further information on evaluating protective methods.

2.5. P5 - Pesticide Selection:

The goal of IPM is to minimize the use of pesticides. Selective insecticides are employed when preventive and other control techniques alone do not provide acceptable results. Principles 5, 6, and 7, which assume pesticide usage, become important in this scenario. Pesticides must be carefully chosen to avoid negative health or environmental consequences [9]. Excessive use of nonselective pesticides in orchards and vineyards in Switzerland in the early 1970s almost wiped out predatory mites and resulted in acaricide resistance among spider mites. Only a pest management program especially intended to protect naturally existing but reintroduced predatory mites could control uncontrollable spider mite outbreaks. Products that are friendlier with beneficial arthropods are preferred to reduce disruption of biological pest control and enhance IPM. Online databases may be used for this purpose. The IOBC Pest Select Database, the IPM Impact Side-effects Database, the Pesticide Properties DataBase at the University of Hertfordshire, and others are among them. Companies that sell biological agents, such as Koppert or Biobest, also offer information on the impact of pesticides on the beneficial arthropods they provide.

2.6. P6 - Reduced Pesticide Use:

The IPM objective of lowering or limiting hazards to human health and the environment is achieved by reducing pesticide dosages, application frequency, and resorting to partial application of pesticides. In reality, national pesticide programs have set a quantifiable time-bound objective of reducing pesticide usage. When expressed in terms of volume utilized, a negative trend is automatically generated owing to a transition to more powerful products. To get around this flaw, Denmark invented the "treatment frequency index," which calculates frequency of usage and dosage at the same time. Although the current authors consider reducing dose rates to be secondary to reducing pesticide use, we recognize it as a tactic on the IPM continuum that can be judiciously combined with others, such as the use of resistant cultivars, disease intensity rather than frequency thresholds, and advanced decision-support systems. The possible impact on the possibility of pesticide resistance developing in the insect population, which is the subject of the next principle, is one factor to consider when applying lower dosages.

2.7. P7 - Anti-Resistance Strategies:

The number of insect species that are resistant to pesticides is growing, putting the effectiveness of many treatments in jeopardy. Insect pest resistance to pesticides was a key driving force behind the creation of IPM. There are many examples of resistance across all pest categories nowadays. For example, the fungus that causes cucurbit powdery mildew, Podosphaera xanthii, rapidly acquired resistance to demethylation inhibitor fungicides, strobilurin, and, more recently, cyflufenamid. Because there are so few novel herbicidal modes of action available, this problem is especially severe in weed control. Traditional farming systems with limited spatial and temporal variety are threatened by the increasing probability of over-reliance on a restricted range of chemicals.

2.8. P8 - Evaluation:

Principle 8 enables farmers to evaluate the effectiveness of crop protection methods they use, which is an essential element of good management. The assessment standards employed are a touchy subject here. According to farmer interviews, the two most often cited measures of effective crop protection technique are absolute production (regardless of profit) and complete absence of pests, i.e., "clean" fields. Traditional evaluation techniques like this may stymie the creation of new options. Multi-season impacts, trade-offs with other production and economic compartments, as well as human health and the environment, may all be covered by an IPM-compatible evaluation. At the cropping system and agro ecosystem level, new IPM-adapted performance criteria and standards of reference may incorporate these variables.

Many of the beneficial impacts of IPM methods last over many years, thus a successful assessment must include all crops in the rotation across several seasons. This is especially important when it comes to weed seed banks, the buildup of soil-borne diseases, pathogen resistance development, and unexpected insect outbreaks. The degree of short-term control achieved by pharmacological measures alone is not the criterion by which "success" is measured, as stated in Principle 4. It is necessary to begin a process of rethinking and reassessing assessment. At the cropping system level, it would stress the assessment of yield, yield stability, and profit across many years. Lechenet et al. show how to evaluate pesticide usage intensity at the cropping system level while taking various trade-offs into consideration [10]. At the farm community level, research and extension activities will create new standards of reference, and performance criteria will become widely disseminated among farmers.

3. CONCLUSION

The European Union is starting on attaining the widespread use of IPM through the Framework Directive on the Sustainable Use of Pesticides. Application of this sustainable pest control strategy to a wide range of biophysical and socioeconomic agricultural conditions is required for widespread acceptance. Aside from the variety of agricultural conditions, IPM practitioners must deal with the complexities of agronomic and ecological processes that must be considered while decreasing pesticide use. The quest for a single universal "one-size-fits-all" pest management technique is unrealistic in the face of such variety. A flexible strategy, on the other hand, is made up of a collection of basic concepts that may be modified to local circumstances. As a result, it makes sense to design a pest control strategy based on basic principles. Using an outcomes-based approach rather than imposing intermediate objectives to apply the set of eight principles may have the additional advantage of promoting adaptability and innovation while also providing environmental and health benefits.

The most important problem for policymakers and program managers is to establish the circumstances that allow farmers to progress along the IPM continuum in the long run. Germany, France, Denmark, Sweden, Italy, and Switzerland are among the European nations that have long backed IPM. This procedure is being started in other European nations. Bridging this gap to guarantee that IPM concepts are incorporated into agricultural methods is much the more difficult in the latter nations. Matyjaszczyk examined the difficulties of widespread IPM adoption in Poland. She emphasizes the need of bolstering state advisory services and striking a balance between administrative assistance and sustainable practices guidance. The ERA-Net C-IPM was recently established by a partnership of 21 nations to develop synergies throughout Europe. This new organization is establishing a funding network to coordinate national IPM initiatives.

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