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REVIEW

The role of guidelines in pest monitoring and warning systems in integrated pest management

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Abstract

The rules and guidelines for integrated pest management specified in Annex III, sections 2 and 3, state "General principles of integrated pest management": Harmful organisms must be monitored by adequate methods and tools, where available. Such adequate tools should include observations in the field as well as scientifically sound warnings, forecasting and early diagnostic systems, where feasible, as well as advice from professionally qualified advisors. As part of Multiannual Programs, the Institute of Plant Protection – NRI in Poznań has been carrying out work and research for many years to develop or modify guidelines for monitoring short- and long-term forecasting of pest occurrence on crops. These guidelines are extremely helpful for farmers and advisers in determining the optimum date of chemical control of pests on plants. Regularly revised and improved the guidelines deal with pests which currently pose a threat to crops. They are developed according to the latest scientific findings and are successfully promoted among professional users and agricultural advisors. These guidelines are standardized to include descriptions of species, life cycles, symptoms of damage/infestation of crops, methods of observation targeted at warning of the need for plant protection treatments, and threshold values of harmfulness. All guidelines include extensive photographic material. Guidelines for the monitoring of pests on orchard plants, vegetables and others are prepared at the Institute of Soil Science and Plant Cultivation – NRI in Puławy and the Institute of Pomology in Skierniewice. Guidelines for about 80 pests of crops are available for public use in the on-line Pest Warning System (Platforma Sygnalizacji Agrofagów, www.agrofagi.com.pl).

Keywords: intergrated control, guidelines, warning system

Since January 1, 2014, pursuant to Directive 2009/128/EC of the European Parliament and of the Council of October 21, 2009, establishing a framework for Community action to achieve the sustainable use of pesticides, all professional users must observe the principles of integrated pest management.

The rules and guidelines for integrated pest management specified in Annex III "General principles of integrated pest management" emphasize the application of all possible and available methods aimed at reducing the development of populations of harmful organisms to a level of harmlessness. It is worth emphasizing that measures and principles of integrated pest management in Polish agriculture are not a novelty. For many years, agricultural producers and advisors have been using different methods of preventing the effects of the intensified occurrence of pests and pathogens. Nationwide rules and methods of integrated pest management require interdisciplinary cooperation between different specialists covering many areas such as entomology, phytopathology, plant cultivation, soil science, etc. Propagating integrated plans for the protection of different types of crops throughout the country requires establishing advisory services for promoting

and supervising integrated protection, changing academic curriculums at all levels of education, and above all, changing attitudes towards the protection of plants and the agricultural environment (Pruszyński 2011; Matyjaszczyk 2013).

Annex III in sections 2 and 3 states:

Section 2: Harmful organisms must be monitored by adequate methods and tools, where available. Such adequate tools should include observations in the field as well as scientifically sound warnings, forecasting and early diagnostics systems, where feasible, as well as the use of advice from professionally qualified advisors.

Section 3: Based on monitoring results the professional user must decide whether or not to apply plant protection measures, and when. Robust and scientifically sound threshold values are essential components for decision making. For harmful organisms, threshold levels defined for a given region, specific areas, crops and particular climatic conditions must be taken into account before treatments, where feasible.

Systematic monitoring of pests is an extremely important element of integrated pest management. It is fundamental for identifying the dangers for crops from harmful organisms, i.e. the phytosanitary status of plants. Monitoring the occurrence of pests allows researchers to determine plant health status for the purposes of determining the optimum time of plant protection treatment, in other words, warning that treatment is needed (Walczak 2010). Adequate use of findings from studies on the occurrence of pests helps minimize the risk of potential crop damage and eliminates the excessive and often unnecessary use of chemical plant protection products, which is emphasized by the Directive on integrated pest management. Monitoring allows for the treatment to be applied at an optimum time, taking into consideration the threshold of harmfulness. Research has shown that treatment at an optimum time reduces pest harmfulness more effectively than the dosage of the product (Jorgenson and Nielsen 1998).

Determining the optimum date of treatment requires knowledge about the pests occurring on crops, their biology and ecology, areas of occurrence or climatic conditions affecting their growth rate, and the ability to assess the pest population or the severity of the disease. Therefore, studies in this area, published as instructions and guidelines, are of great importance, since they help develop, modernize and improve methods of monitoring pests on crops (Pruszyński and Walczak 2006; Walczak 2010).

The significance of important pests of cultivated plants changes with time. The changes are brought about by many factors, such as intensive farming, reduction of biodiversity in agriculture, facilitations in agrotechnology, and the cultivation of single varieties on large areas having different resistance to pests and diseases. One of the most important factors in recent years has been climate change (Walczak and Tratwal 2008; Walczak *et al*. 2015).

Climate change creates new challenges for plant protection. Air temperature, as well as air and soil humidity are important factors influencing the development of pests of cultivated plants. The rate of pest development on plants, count, population dynamics, extent of occurrence, intensity of feeding or harmfulness depend on the temperature and humidity of the environment. Global warming may also create conditions for the development of multiple pest generations. Observed changes in climate contribute to the extension of the plants' growing season by about 1 month due to warm autumns (Walczak *et al*. 2015).

During the growing season, pests may occur in particular towns, counties or provinces at different times, depending on the microclimate, i.e. the regional factor. Nationwide, the differences can be quite significant, even up to a month. Therfore it is extremely important to monitor pests in small areas, or even on individual plantations, something that is often underestimated by producers or consultants (Bubniewicz *et al*. 1993; Pruszyński and Walczak 2006).

Early warning is based mainly on short-term forecasting of the development of diseases and pests, and the assessment of the progression of such phenomena taking into consideration the date of the occurrence, and economic criteria.

Nowadays, warning of the need for plant protection treatments is very often based on monitoring pests, which for the purposes of short-term forecasting is conducted by the farmers themselves. It involves the correct interpretation of observations to determine the optimum time of pest control.

Good practices in plant protection clearly emphasize how important it is to know the health of the cultivated plants which are to be protected. Thus, extreme significance should be placed on scientific research which leads to the development, modernization and perfection of observation methods and control of pests on cultivated plants.

In short, determining the optimum time for a treatment is not easy. It requires expert assessment of the development and the intensity of diseases, the biology and count of pests, as well as basic tools to assist the advisors or farmers. These include both the simplest tools, such as a bucket trap, a yellow pan, a sticky colour trap, as well as more technologically advanced ones, e.g. computer software aiding the determination of the optimum time of the treatment, an automated meteorological station, etc.

One of the most important elements in monitoring pests is the assessment of their harmfulness. It is a one-time assessment made at a time strictly specified for each pest, i.e. during a particular developmental stage of the host plant or the pest. It is a time when a given

Table 1. Some examples of guidelines for winter wheat and related agrophages

Crop	Agrophages
Winter wheat – diseases	Powdery mildew – *Blumeria graminis*
	Septoria leaf spot – *Phaeosphaeria nodorum, Mycosphaerella graminicola*
	Brown rust – *Puccinia recondita* f. sp. *tritici*
	Take-all disease – *Gaeumannomyces graminis*
	Wheat tan spot (DTR) – *Pyrenophora tritici-repentis*
	Stem-base disease – *Oculimacula yallundae*
	Fusarium diseases – *Fusarium* spp.
	Ergot – *Claviceps purpurea*
Winter wheat – pests	Aphids – *Rhopalosiphum padi*, *Sitobion avenae, Metopolophium dirhodum, Rhopalosiphum maidis*
	Cereal leaf beetlel – *Oulema* spp.
	Saddle hedge midge – *Haplodiplosis marginata*
	Cutworms – Noctuinae

pest will no longer cause significant damage. Thanks to such data, it is possible to annually publish information regarding the health of cultivated plants in Poland, as well as to forecast the occurrence of harmful organisms in the following year (Tratwal *et al*. 2017). This is the only publication of this type in Poland. The results of the nationwide monitoring of the harmfulness of pests have indicated that throughout the years there have been periods in which the economic significance of individual pests increased or decreased cyclically. This was caused by changes in the acreage, selection of varieties, level of fertilization, facilitations in agrotechnology, gradation tendencies characterizing some species, as well as climate changes, which influence the species composition and the level of harmfulness of pests (Walczak and Tratwal 2008).

Monitoring makes it possible to disseminate information about the invasion of new pests into Poland from other countries. This plays a very important role in the process of preventing the spread of "new" pests. One example may be the western corn rootworm, which was seen in August and September 2005 in the Podkarpackie province (Sahajdak *et al*. 2006).

The national action plan to reduce the risks associated with the use of plant protection products, hereinafter referred to as the "national action plan", implements the obligations of Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides. This plan sets out the objectives to be achieved in reducing the risks associated with the use of plant protection products for human health and the environment. The key objective for Poland in relation to the implementation of the national action plan is the promotion of general principles of integrated pest management and the prevention of threats related to the use of plant protection products.

For advisory services or farmers the different Integrated Pest Management (IPM) Guidelines are very informative. IPM Guidelines usually consist of IPM programs, protocols, checklists, and definitions which are very useful for coordinating the use of all available agricultural methods being practiced. The development of the IPM Guidelines was first encouraged by independent researchers (Stern *et al*. 1959) and put into practice by independent organisations such as the International Organization for Biological Control (IOBC).

Under the national action plan, nine measures have been implemented, including promotion of the general principles of integrated pest management. This has been achieved by the following and other actions:

- the creation of an on-line Pest Warning System, a platform and tool for sharing experience and transfer of knowledge between scientists and professional users of pesticides and farmers;
- providing farmers and advisors with the tools necessary to implement the requirements of integrated pest management, such as guidelines on the integrated protection of specific crops, support systems for decision making in plant protection, guides for reporting pest occurrence, integrated pest management plans, results from post-registration testing of cultivars, etc.

As part of Multiannual Programmes, the Institute of Plant Protection – NRI in Poznań has been carrying out research for many years to develop new guidelines, or modifying existing ones for monitoring short-term and long-term forecasting of pest occurrence on crops. These guidelines are extremely helpful to farmers and advisers in determining the optimum date for chemical control of pests on plants (Table 1): http://www.agrofagi.com.pl/28,metodyki-sygnalizacji-i-monitorowania-agrofagow.html. Regularly revised and improved guidelines regarding pests that

currently pose a threat to crops, based on the latest scientific findings, are successfully promoted among professional users and agricultural advisors. These guidelines are standardized to include a description of species, life cycle, symptoms of damage/infestation of crops, methods of observation targeted at warning of the need for plant protection treatments, and threshold values of harmfulness. All guidelines include extensive photographic material. Guidelines on the monitoring of pests on orchard plants, vegetables and others are prepared at the Institute of Soil Science and Plant Cultivation – NRI in Puławy and the Institute of Pomology in Skierniewice. Guidelines for about 80 crop pests are available for public use in the on-line Pest Warning System (Agrophages monitoring system: www.agrofagi.com.pl).

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