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INTEGRATED PEST MANAGEMENT: WHEN GROWERS BECOME STRATEGISTS

Slugs, weeds, fungi, insects, bacteria, rodents,... : cultivated plants have to contend with lots of pests. The aim of integrated pest management is not to eradicate them but to keep them at bay by a combination of time-honoured methods and the latest tools provided by the life sciences.

Cultivation does not mean getting rid of all living species except for one. Advocates of this approach thought they could use plant protection products to clear the countryside of crop pests. But nature has more than one trick up its sleeve: in response to pesticide pressure many species developed resistance, with the result that some treatments soon proved ineffective. Worse still, because their natural predators had vanished some minor pests started to proliferate, causing damage of a kind never experienced before. Farming under the 'plant protection umbrella' proved to be an illusion. Instead, parasitism, predation and antagonism between living organisms are all natural processes that can be utilised to avoid or to soften the violent confrontation between a crop and its pests. Empirical agricultural practices like tillage and crop rotation have been analysed to examine their effects on the interactions between pests and cultivated plants. Lastly, plant genomes have been explored as a pool of disease and pest resistance genes.

Integrated pest management uses all available means, favours preventive measures and develops low-input strategies. Pesticides are not ruled out, but they are not considered a production factor. Treatments are recommended only when experimentally determined risk levels or 'tolerance thresholds' are exceeded. Integrated pest management aims only to use products that are compatible with the system as a whole.

The basis of integrated pest management is knowledge. It evolves in small steps, taking in relevant progress in a wide range of disciplines including genetics, chemistry, mechanics and ecology. It requires practical agronomists whom growers can relate to and who address problems as a whole and are able to draw up concrete plans of action.

Integrated pest management requires regular observations in the field. Forecasting models need to be continually checked against real situations if they are to develop and remain valid. Their relevance has to be reviewed annually if the warnings and advice issued by the various decision support organisations are to retain their credibility.

In Wallonia, advance warnings for farmers are drafted by specialists in the particular field (diseases, pests, etc.) Each of them analyses the reports from observer correspondents from a variety of institutions (provincial or regional government departments, research centres or universities) within a system that covers the whole area and uses standardised observation methods. The reports describe the situation observed within a network of observation fields. Attention is drawn to risks, issues are highlighted and advice is provided. However, they are no substitute for the farmer's knowledge and skill. Rather than a decision support service, these recommendations give farmers food for thought, enabling them to make fully informed decisions.

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INTEGRATED PEST MANAGEMENT: A UNIVERSAL APPROACH

Knowing the pests, assessing the risks, avoiding or reducing exposure, determining tolerance levels: the integrated pest management way can be followed in all crops, and sometimes even in livestock farming. Through their research, the decision support tools they design and drive, and the numerous information transfers to farmers which they organise, many CRA-W researchers play a part in developing integrated pest management. Here are some personal accounts:

Vincent César

"Controlling potato blight requires preventive fungicidal treatments. The support of the warning system, a decision support system which models the emergence and development of blight as a function of weather conditions, enables fungicidal treatments to be carried out at precisely the right times, with the result that fewer treatments are needed."

Louis Hautier

"Pests are controlled by a number of specialist beneficials, such as parasitic hymenoptera, hoverflies and so forth, or general-purpose beneficials like lacewings and carabid beetles. That makes it important to preserve and promote that diversity in the field by favouring an environment that ensures the sustainability of these insects in agricultural ecosystems and thus take advantage of the free control service they provide for farmers."

Jean-Pierre Goffart

"Another aspect of integrated pest control is correct management of crop nitrogen fertilisation. Excessive nitrogen application often leads to pathogen development because of the surplus of biomass. That's why the decision support tools developed at CRA-W based on monitoring crop nitrogen status contribute to healthy, integrated crop management."

Laurent Jamar

"Scab is the fruit growers' bugbear. The ascospores that cause the infections are dispersed between March and June. Pinpointing the dispersals and determining their intensity are essential for effective protection. The daily measurements taken in orchards by CRA-W staff enable the risk forecasting models to be refined each year, thus backing up the regional warning system."

José Wavreille

"Neonate piglets must acquire good passive immunity if they are to be sufficiently protected. Research carried out at our experimental piggery documents the effects of management methods on the immunological quality of the colostrum and the quantity produced. Initial experiments involve using fermented potato proteins or yeasts (Saccharomyces cerevisiae) as feed additives to determine their effects via suckling."

Christiane Fassotte

"In horticulture, from orchards to nurseries and not forgetting strawberry plants, integrated management of bio-aggressor arthropods takes various forms: detection, inventory and surveillance, risk analysis, making recommendations, decision support, research and promoting alternative methods. The Entomology Laboratory has been involved in this line of work for more than 30 years."

Guillaume Jacquemin

"Unlike most other countries, in Belgium official testing for cereal cultivar registration is conducted without fungicidal treatment or growth regulators. Doing things that way enhances each cultivar's ability to tolerate or even resist fungal diseases and lodging. This is part of integrated pest management."

Sophie Schmitz

"When faced with a plant health problem an accurate diagnosis enables specific means of control for the pathogen or pest in question to be deployed and promotes better pesticide management. Tests for detecting soil-borne pathogens are also a useful decision support tool when planting a susceptible crop on potentially infected land."

Virginie Decruyenaere

"The dairy heifer breeder has diagnostic tools for managing the use of cattle antihelminthics correctly and enabling the animals to develop their immunity. These include cattle behaviour, faecal analysis, pepsinogen determination, etc. Managed use of antihelminthics reduces the risks of resistance. Combined with proper feeding, this promotes normal growth in young cattle in the first year of grazing."

Florence Censier

"After forty years with no reports the saddle gall midge, Haplodiplosis marginata, is once again threatening cereal crops in Belgium. My thesis is aimed in particular at developing a sex pheromone trap. Ultimately, this tool could be used by farmers to assess populations in their fields. Initially, its main value will be to researchers studying this elusive insect."

Quentin Ledoux

"The plant uses almost imperceptible cell signals to deploy the whole panoply of its natural defence mechanisms against certain pests. Here at CRA-W we are now able to detect those signals by fluorescence microscopy, giving us a better understanding of plants' hidden resources for controlling their pathogens."

Jean-Pierre Jansen

"The use of plant protection products that are selective for beneficial insects underlies most of the success in integrated management of crop pests. If you get rid of pests' natural enemies you are continually having to control those insects whereas, by shifting the balance in favour of natural enemies, the problem can often be solved for good."

Bertrand Colignon

"The progressive domestication of plants, along with the intensification and globalisation of agriculture, have considerably undermined cultivated species' genetic resistance to biotic stress. Proteomics, based on recent progress in molecular biology, enables conventional breeding schemes to be oriented towards distributing material with lasting pathogen resistance."

Emmanuelle Escarnot

"Breeding and providing farmers with spelt and wheat varieties that have low nitrogen needs, are disease tolerant, resistant to lodging and have a canopy density allowing them to compete with weeds – that's our contribution to integrated pest management. Using old varieties in our breeding schemes enables resistance genes to be incorporated into current elite varieties."

Alain Bultreys

"In the area of plant bacterial diseases, accurate diagnosis, knowledge of pathogen biology and appropriate preventive methods are often the most effective means of control. Our work is therefore directed at identifying specific problems arising in Wallonia and characterising the causal pathogens in order to target the management methods."

Stéphan Steyer

"In October, when the winter barley emerges and the temperatures are favourable (> 14°C), the fields are invaded by aphids which may or may not carry the barley yellow dwarf virus. The analyses performed at our laboratory enable the percentage of aphids carrying the virus to be determined. Low level of viruses detected? No insecticide treatment recommended, even if aphid numbers are high!"

Michel De Proft

"Drawing up an accurate warning is not so easy, even when the situation is clear-cut. Each time we do it we have to think about the information expected according to the season, the big storm the night before, the crop's slightly late development, and so on. The relevant information, all the relevant information and nothing but the relevant information: a mid-season warning needs to hit the target without beating about the bush. What's the hardest thing about it? Definitely the hardest thing is being succinct. After all, a warning is not a treatise, nor is it a lesson: you have to say it all in a few lines."

SOLVING THE MYSTERIES OF THE ORANGE WHEAT BLOSSOM MIDGE (*SITODIPLOSIS MOSELLANA*)

Between mid-April and mid-June the adult orange wheat blossom midges – tiny little midges – emerge in the fields in one or more waves. Having been fertilized, the females fly off in search of ears of wheat to lay their eggs in. The eggs hatch a few days later and the larvae then feed on the grain. On completion of their development the larvae drop from the wheat and burrow into the soil, where they remain until the following spring.

The broad lines of this insect's biology have been known for a long time, but agronomists were still missing one critical element: the factors that determine the emergence date. The fact is the adults only live for a few days. If they emerge once the wheat has started heading, oviposition can take place, resulting in yield and quality losses; frequently, though, emergence does not coincide with the vulnerable stage of the wheat. In that case the insect fails to reproduce and the crop is unscathed. With no way of predicting emergence it was not possible to assess the risk or to advise farmers. CRA-W researchers therefore spent several years attempting to understand what governs the insect's development. From 2007 to 2010 the insect was observed as it developed in the soil, and flight patterns were then determined with the aid of pheromone traps. Extensive data were collected in the field and compared with meteorological data from other sources. The development conditions were progressively identified, namely the need for cold to break the diapause, the temperatures needed to stimulate emergence from the cocoon, heavy rain to trigger pupation, etc., until, finally, a predictive model for adult emergence was built. The model was validated by testing under controlled conditions where emergence was prompted. Then, in 2011, 2012 and 2013 it was used to predict the dates of the first insect flights in the field, proving accurate to within a day for three successive years.

One gap in our knowledge has been filled: it is now possible to predict harmful coincidences and include that information in the warnings to cereal growers. The new knowledge acquired also enables young adults ready to lay to be produced at will and their emergence to be programmed. This possibility has led to the development of a simple, effective method for testing wheat varieties' resistance to the insect.

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INTERROGATING THE AIR AND THE RAIN IN ORDER TO UNDERSTAND WHEAT DISEASES

Like pollen, wheat pathogenic fungus spores are microscopic propagules that can take to the air in order to disperse. Little is known about their aerial travel and so, until now, predictive models for disease development have assumed the air-borne inoculum to be 'all over the place'. Obviously, such a vague description cannot be used to predict either the start of emergence or the severity of infection in a wheat field, and the only option is to watch for the early symptoms in order to guess the pressure level of the different diseases and adjust the protection applied, if necessary. However, by the time the symptoms appear the plant is already infected and part of the yield potential has already been lost. In practice, advice to cereal growers is therefore based mainly on experience from previous years and on what is known about disease development according to the weather conditions once the plants are infected.

CRA-W and UCL attempted to measure spore flows of the main wheat pathogens before they infected the plants. This was done by positioning spore sensors with an intake of 14 m^3 air per 24 hours in a network covering the main field crop growing areas of Wallonia and linking them up to weather stations. Tests were set up near each sensor to monitor disease emergence and development and test the protection schemes. The spores collected were identified with the aid of molecular tools which were used to make a daily assessment of the spore concentration of the main wheat diseases in the air. The same method was used at the same time to measure the spore concentration leached by rain.

This unusual approach has already resulted in notable progress in understanding the epidemiology of leafblotch by demonstrating that the epidemiological phase includes sexual cycles that produce spores which are dispersed by the wind and are likely to directly infect the upper leaf levels. The results will be used to correct the predictive models which hitherto assumed that wheat leaf blotch spread from the base of the plants only. Ultimately, such observations could be incorporated directly into the advice given to farmers in the growing season to enable them to adapt the crop protection to the threats measured ... in the air!

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LOOKING AHEAD TO REDUCE HERBICIDE USE

Bindweed, silky apera, wild oats ... don't they have pretty names, those weeds that gardeners and farmers struggle so hard to control! They compete mercilessly with cultivated plants. Yield losses in a weed-infested field can be considerable, but that's not all: a prudent grower fights weeds because he knows that allowing them to flower and fructify is only storing up trouble for coming seasons. There's no getting away from it – weeds must be controlled. As they rarely, if ever, have natural enemies that can be roped in to render them harmless, the answer is frequently to use herbicides to control these crop pests. When the weather conditions are favourable, tillage implements can also be used to destroy young weeds. But it would be a mistake to think only in terms of chemical or mechanical 'weeding'. The fact is that a field's weed population is closely linked to the cropping system, each part of which affects weed dynamics. The weed population can vary in composition and density according to crop rotation, the tillage system and intercrop management. Agricultural levers can be actuated to restrict the development of the most undesirable weeds. For example, blackgrass trials ongoing for the last four years have shown that both emergence and seed production decreased drastically if the sowing date was put back. Tillage likewise has a perceptible depressive effect on blackgrass populations. That's useful to know for anyone dealing with heavily infested land, especially if there is a large proportion of herbicide-resistant blackgrass!

Another point is that weeds and cultivated plants compete for light. Breeding programmes for various crops are aimed at creating varieties that achieve rapid ground cover as a means of limiting weed germination.

Agricultural, chemical, mechanical and genetic means: integrated weed management is advancing along various routes.

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