PHERA

pheromones for row crop applications

> **I'm very proud of what we have accomplished over the past few years. Together we have developed a whole new technology platform, which will make pheromones affordable for all farmers.**
>
> Irina Borodina, co-founder of BioPhero and technical manager of the PHERA Project

NEWSLETTER SEPTEMBER 2022

As field trials of pheromone-based mating disruption continue, the PHERA Project is entering a commercial phase. Partners are beginning to develop marketable pheromone products based on results obtained through the project, and one consortium partner has been acquired by FMC Corporation, neatly demonstrating the significant impact of the PHERA Project.

Biological farming methods increase rice yield in Bangladesh

A field trial in Northern Bangladesh has expertly demonstrated how integrated pest management (IPM) can increase yields while minimising the use of chemical insecticides. It is a win-win solution for farmers and the environment alike.

The field trial was carried out by Russell IPM of the UK under the auspices of the PHERA project with the objective to provide a viable alternative to chemicals. Farmers in Bangladesh typically treat their rice crops with chemical insecticides 5-8 times every season, explains Dr Nayem Hassan, Russell IPM's Director of Research.

"When these farmers see the first whitehead in their rice field they panic, and not without reason, as stem borers can spoil their entire crop and, thus, their livelihood. They rush off to the agrochemical dealer and buy conventional synthetic chemicals because they haven't got an alternative. Now we can tell them there is an alternative," he says.

Mating disruption dispenser in rice in Bangladesh - with a stem borer in the background (image: Russell IPM)

Ideally, pesticides should be applied to keep pests, diseases and weeds below their economic damage threshold without harming humans and the environment. However, this has not been the case historically. IPM seeks to minimise the use of toxic chemicals by applying a combination of biological, chemical, physical and cultural crop management practices.

In this trial, the first of its kind in Bangladesh, Russell IPM utilised a three-dimensional approach to successfully control one of the most destructive pests of rice crops in Asia – the yellow rice stem borer.

First, Russell IPM applied mating disruption to control the stem borers. Mating disruption is a method that prevents insects from multiplying by spreading their pheromone in a field. Female insects release a pheromone to attract a mating partner, producing an olfactory trail for the males to follow – unless a farmer scrambles it by spreading the same pheromone in the field. Now, with

the entire field smelling like females, the insects cannot find each other to mate and proliferate.

To reduce the initially high population of stem borers, Russell IPM also included a one-off application of a locally registered biological insecticide, Biomax-M. Biomax-M contains a microbial extract as its active ingredient, a natural fermentation product of the soil bacterium *Streptomyces avermitilis*.

Finally, to make the rice plants generally more resilient, Russell IPM applied its own Lycomax, a microbial insecticide that combats the pupal population in the soil and debris. With more than 15 years of research and development behind it, Lycomax has proven to produce healthier plants that require less fertiliser, pesticide and water due to their enhanced ability to defend themselves against pests, disease and environmental stresses (see box).

The trial was carried out in the intermediate Kharif-II growing season from July to October 2021. The trial area included about 10 hectares pooled from several farmers. Bangladesh may grow rice on more than 10 million hectares of land, or about 80% of its cropping land, but the average farm size is no larger than half a hectare.

Russell IPM found that the occurrence of whitehead and dead heart – clear signs of stem borer infestation – in the trial plot was about half of the neighbouring control plot. More importantly, the yield was over 40% higher in the trial plot. Thus, the field trial irrevocably showed the advantage of biological methods, not only for the farmer but also for the environment. Using less and fewer chemicals will benefit other insects, animals and humans.

Bangladesh prioritises biological solutions in a quest to reduce its consumption of pesticides. In this regard, there are over 40 biological insecticides have been registered in Bangladesh. Since 2018, Russell IPM has collaborated with the Bangladesh Agricultural Research Institute and the Department of Agricultural Extension on a government-funded, five-year project for the development of IPM programmes for vegetables, fruits and betel vine. Now the time has come to develop a biorational solution for rice.

Russell IPM, therefore, plans to conduct further IPM field trials in Bangladesh during the other growing seasons, Dr Shafiqul Aktar, Russell IPM's Country Manager in Bangladesh, says.

What is Lycomax?

Lycomax is a specialised soil amendment product that deploys nature's own weapons to control pests. It recharges the soil with the same beneficial organisms that nature uses to keep insect populations in balance, such as the parasitic soil fungus *Metarhizium anisopliae* and other naturally occurring soil micro-organisms and plant nutrients. As a result, Lycomax controls pests in several ways:

- Re-establishing the soil's microbial fauna to allow for growth of natural pest enemies
- Increasing plant nutrient absorption for enhanced crop growth and yield
- Boosting plants' systemic acquired resistance (SAR) analogous to the human immune system

As Lycomax is based on natural organisms, which can grow and multiply in the soil, one simple application provides season-long protection.

PHERA partner bought by FMC

FMC Corporation has acquired PHERA partner BioPhero at a price of $200 million. The purchase of the Danish pheromone manufacturer signals that the agricultural industry is moving in a more sustainable direction.

“This acquisition demonstrates our continuing commitment to invest in biologicals and adjacent technologies, expanding our world-class portfolio while advancing sustainable agriculture,” said Mark Douglas, FMC president and CEO, in a press release.

FMC Corporation is one of the world’s largest producers of crop protection solutions. With insecticides accounting for 60% of its revenue of $5.05 billion in 2021, the company is solidly anchored in chemicals. Yet, FMC is now looking to expand its portfolio with pheromones.

The challenge is that pesticides may be effective at increasing food production, but they are also harmful to humans and the environment (see article next page). Yet, with 20-40% of crop yields being lost to pests globally, according to the Food and Agriculture Organisation, pest control is a neccessity. Many farmers are therefore turning to Integrated Pest Management (IPM), which uses a combination of management strategies to minimise the chemical input – and pheromones are very relevant in this context.

Pheromones are natural molecules secreted by insects to attract a mate. If a farmer disperses the same pheromones in a field, the insects’ I-am-here pheromone trail is veiled, and they can’t find each other. No mating means no eggs and no plant-munching larvae. It is pest control in a safe and environmentally friendly way.

What BioPhero has done is to step-change the cost of pheromones. Instead of using chemical synthesis, the company has developed a whole new technology based on yeast fermentation to produce affordable pheromones at an industrial scale - and the technology has been developed under the auspices of the PHERA Project. The lower cost means that pheromones can be used in row crops dependent on economy of scale.

The acquisition deal was closed in August 2022.

The PHERA Project seeks to broaden the scope for pheromones. Although the efficacy of mating disruption has been known for more than 20 years, the cost of pheromone production has been a barrier to its deployment. Pheromones have until now been manufactured synthetically, but the PHERA Project is scaling up a new fermentation method for production of pheromones at an industrial scale. The lower cost will make pheromones suitable for use in large-scale row crops. Read more here

FMC Corporation has acquired PHERA partner BioPhero ApS (image: collage/Shutterstock)

Synthetic insecticides have been exceptionally successful in agriculture for just about 100 years. Why stop?

Pheromones make perfect sense against a backdrop of the history of pesticides. In fact, the PHERA Project is very much a product of the evolution of pest management away from chemicals and towards a more sustainable approach.

The first insecticides were basically the most poisonous inorganic chemicals man could find – compounds like lead arsenate and calcium arsenate. They were therefore happily replaced with DDT and other organochlorines in the 1940s. The organochlorines were in turn phased out in favour of organophosphates in the 1960s, carbamates in the 1970s, pyrethroids in the 1980s and neonicotinoids in the 1990s (in contrast, herbicides, constituting by far the largest proportion of today's pesticide use globally,[i] only became common in the 1960s-1970s).

DDT is an excellent example of our love-hate relationship with pesticides: The reasonable cost, effectiveness and persistence of DDT made it an instant hit in the 1940s and 1950s – until some of those advantages turned out to be less clearcut. Rachel Carson's book Silent Spring from 1962, which highlighted how DDT accumulates in the food chains to the detriment of birds and other non-target organisms, became a catalyst for reducing the use of DDT. Whereas it is still being debated whether DDT is harmful to humans, everyone agrees that DDT is excellent at controlling vector-borne diseases, leading to its continued use in several developing countries (image: Shutterstock)

What all these – synthetic – insecticides have in common is that they are poisons designed to kill pests. Not surprisingly, that makes them potentially toxic to other organisms as well, including beneficial insects, birds, fish and humans. Many insecticides target sites in pests' nervous system that are identical or similar to human ones.[ii]

Right up until today, the organophosphates have remained among the most widely used insecticides, but last year, the US decided to do as the EU and ban the all-time favourite chlorpyrifos, a nerve agent affecting insects and humans alike. The neonicotinoids, currently the most popular family of insecticides in the US, may not be far behind. The EU has banned three of them – imidacloprid, clothianidin and thiamethoxam – to protect bees, and the US Environmental Protection Agency concluded in June 2022 that the same trio is "likely to adversely affect" up to 79% of endangered species in the US.[iii]

History repeats itself

Each new family of chemical insecticides has been promoted as more ecological than the previous one. Time tends to prove us wrong. The pyrethroids and neonicotinoids may be less toxic than carbamates and organophosphates to vertebrates like mammals, birds and fish, but they are more toxic to invertebrates:[iv] Since the introduction of the neonicotinoids, US agriculture has allegedly become 48 times more toxic to insect life.[v]

In an ideal world, an insecticide should kill a targeted pest without harming non-target organisms. In the real world, this is not the case. Pesticides are difficult to confine. Sprayed or spread across entire agricultural fields, they are susceptible to leaching, runoff and drift, being carried by the wind to neighbouring fields, natural areas and homes.[vi]

Every year, millions of farm workers and other people around the world are poisoned by synthetic pesticides, leading to more than 10,000 unintentional deaths.[vii] Not helped by the fact that wealthy states are exporting hazardous pesticides to poorer countries,[viii] while the trade in counterfeit pesticides has grown into "one of the world's most lucrative and least understood criminal enterprises," according to Géraldine Kutas, Director General of CropLife Europe, the agrochemical industry's trade organisation in Europe.[ix] Add to this a range of chronic health effects caused by insecticides such as cancers, respiratory diseases, genetic disorders and developmental disabilities in children.[x]

Insecticides have done a lot of good

Proponents of insecticides argue that we need them and other pesticides to produce enough food for the world's growing population. They point out that pesticides have played a major role in the consistent increase in agricultural output. In addition, insecticides are not only used to protect crops and preserve food and materials, they also constitute an important weapon in the fight against dangerous vector-borne diseases like malaria, dengue and Lyme. More than 2 billion mosquito nets treated with pyrethroids have been distributed around the world since 2004, averting almost 70% of malaria cases in sub-Saharan Africa.[xi,xii]

Mosquito nets epitomise the search for new insecticides. In newer nets, the pyrethroids have had to be combined with the synergist piperonyl butoxide. Why? Because mosquitoes develop resistance to the pyrethroids. This is the bane of chemical insecticides. It is only a matter of time before pests develop resistance to most chemicals used against them. Around the world, more than 500 pests have developed resistance to over 300 different insecticides.[xiii] It's Darwin's natural selection in action. Not only does this mean the pest no longer is killed by the insecticide. The pest may even develop a liking for crops laden with neonicotinoids (as neonicotinoids are derived from nicotine this should give rise to sympathy amongst smokers).[xiv]

Insect resistance is another nail in the coffin of conventional insecticides. Thus, opponents and proponents agree that it is necessary to complement chemicals with other tools. CropLife Europe, the trade association of the agrichemical industry in Europe, talk about producing "more with less", highlighting Integrated Pest Management (IPM),[xv,xvi] and CropLife America, the US equivalent, is tweeting about IPM: "Not only is integrated pest management helpful to farmers, it's also helpful to the environment!"[xvii] As farmers have fewer and fewer insecticides to choose from, pheromones present themselves as a sustainable alternative.

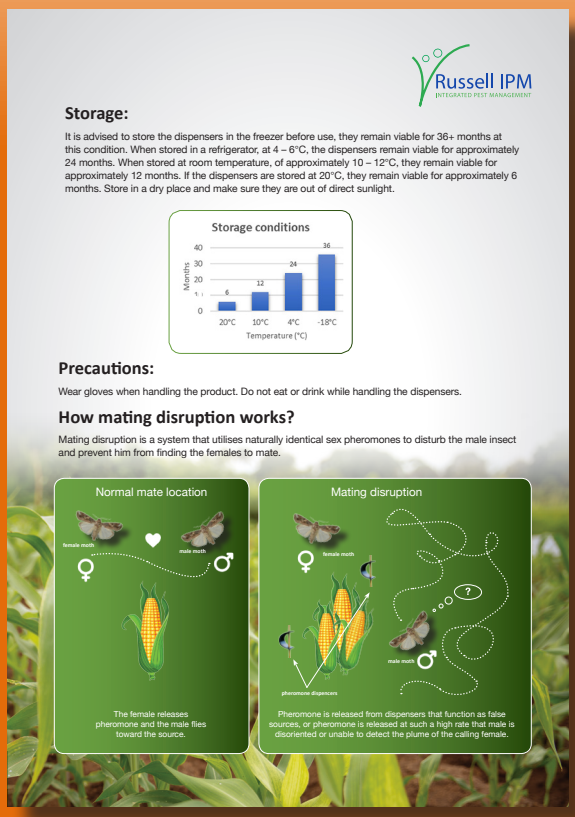
Pests like the fall armyworm develop resistance to pesticides making them increasingly difficult to control with conventional chemicals (image: Shutterstock)

Insecticides have played an important role in keeping one of the world's most dangerous animals in check, the mosquito, which spreads diseases like malaria (image: Shutterstock)

[i] FAOSTAT
[ii] Pesticides and Human Health
[iii] EPA Finalizes Biological Evaluations Assessing Potential Effects of Three Neonicotinoid Pesticides on Endangered Species
[iv] Applied pesticide toxicity shifts toward plants and invertebrates, even in GM crops
[v] An assessment of acute insecticide toxicity loading (AITL) of chemical pesticides used on agricultural land in the United States (plos.org)
[vi] Environmental and Economic Costs of the Application of Pesticides Primarily in the United States
[vii] The global distribution of acute unintentional pesticide poisoning: estimations based on a systematic review
[viii] OHCHR | States must stop exporting unwanted toxic chemicals to poorer countries, says UN expert
[ix] A record number of 1 346 tonnes of illegal pesticides taken off the market in 2020 global operation Silver Axe | Europol (europa.eu)
[x] Pesticide Risk Assessment - CABI.org
[xi] Factors associated with use of insecticide-treated net for malaria prevention in Manica District, Mozambique: a community-based cross-sectional survey
[xii] Malaria No More Proud of its Contribution to the Global Milestone of 2 Billion insecticide-Treated Mosquito Nets delivered since 2004
[xiii] Science for Environment Policy: Biodiversity slows spread of pesticide resistance
[xiv] The more pesticides bees eat, the more they like them
[xv] https://croplifeeurope.eu/more-with-less/
[xvi] https://croplife.org/news/how-ipm-keeps-crops-and-foods-safe/
[xvii] https://twitter.com/croplifeamerica/status/1245368591349952512

PHERA prompts development of commercial pheromone products

PHERA partner Russell IPM of the UK is now offering commercial pheromone products for the control of the fall armyworm. This destructive pest poses a serious economic threat to farmers worldwide with its appetite for more than 80 different plants, including important food crops like corn and rice. Exacerbated by an unsettling ability to develop resistance to common insecticides, the fall armyworm is becoming increasingly difficult to control. It is in this light that Russell IPM has developed new solutions based on mating disruption for sustainable control of the fall armyworm. The company uses the insect's own sex pheromones to disrupt its reproduction cycle.



Horizon 2020
European Union Funding
for Research & Innovation

Bio-based Industries
Consortium

The PHERA project has received funding from the Bio-Based Industries Joint Undertaking under the EU's Horizon 2020 research and innovation programme under grant agreement No 886662.

PHERA Project Partners:

BioPhero

Russell IPM
INTEGRATED PEST MANAGEMENT

SEDQ
Healthy crops in our hands

Fraunhofer IBP

NovAgrica
Biological Products & Solutions

BPF
BIOPROCESS PILOT FACILITY

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