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Symposium Session Topics

Session Number	Session Title	Chair
1	**Opening Session**	**Dr Ian Baxter & Prof. Tariq Butt** (IBMA UK & Swansea University)
2	**Vectors and Nuisance Pests**	**Dr Peter McEwen** (PKMC Consultants)
3	**Semiochemicals**	**Dr Mary Ellis** (PheroSyn)
4	**Tree Health**	**Richard Hunter** (Confor)
5	**Bee Health and Entomovectoring**	**Dr Erica Shelley** (Best for Bees)
6	**Microbial Biopesticides**	**Dr Steve Edgington** (CABI)
7	**AI and Sensor Applications**	**Dr Ginu Rajan** (Cardiff Metropolitan University)
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11	**Investment & Commercialization Landscape**	**Mark John** (Tramshed Tech)

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Sensing Solutions for Soil Biodiversity and Carbon Monitoring: From Acoustics to Biosensing

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Soil carbon dynamics and biodiversity are intimately linked and could make substantial contributions to Net Zero and Biodiversity Net Gain objectives and provide information to construct effective tools for farmers to prevent soil-based pathogenicity and pest outbreaks; all very high-value outcomes towards sustainability in the agricultural sector. The challenge of monitoring the poorly understood dynamics of soil carbon and soil biodiversity is becoming a priority but remains extremely daunting. A reason for this is that soils provide a uniquely challenging environment for effective monitoring and sensing in situ using practical solutions. The three-dimensional dynamic diversity of soil; part living, part aqueous, part gaseous matrix of extreme chemical complexity that is variable temporally and spatially has traditionally required discrete destructive and disruptive analyses. At UWE, we are developing platform technologies that can help meet some of the key challenges in the field with innovation, simplicity and a flexible sensing concept. We are at an early stage, however there is potential for combining technologies, such as electrochemical (bio)sensing, trainable multiplexed gas sensors and acoustic monitoring, to provide a practical and cost-effective solution for effective monitoring that will allow us to understand and model carbon and biodiversity within the soil profile over relevant scales to make sense for farming.

Is *Drosophila Suzukii* a Vector for Mycotoxin Producing Fungi Contaminating Cultivated Blueberries?

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Blueberries contain high levels of phytochemicals that protect against several metabolic disorders thanks to their remarkable antioxidant and anti-inflammatory properties. Therefore, they are considered one of the five foods certified as healthy by the FAO (Gonçalves et al. 2022). However, due to their high susceptibility to postharvest molds such as *Alternaria* spp., *Botrytis* spp., and *Aspergillus* spp., blueberries are very challenging to preserve. These molds contact or contaminate fruits in the field and continue their spread during postharvest, thereby causing important food loss. Furthermore, blueberries are often infested with the worldly distributed pest *Drozophila suzukii*, during their cultivation as well as after their harvest. Female adults of this insect lay eggs in blueberries; therefore, they are suspected of playing an important role in spreading fungal spores among fruits. To investigate this hypothesis, this study evaluated mold contaminations in blueberries sampled from the Italian market and demonstrated the role of the pest in its spread. Blueberries were found to be contaminated with several fungal genera mainly Alternaria spp. followed by *Botrytis* spp. and *Aspergillus* spp. In addition, *Fusarium* and *Colletotrichum* were also present at lower frequency compared to the genera. Moreover, (decontaminated) sterilized blueberries placed in contact with adults of *D. suzukii* captured from the field showed a high rate of contamination compared to the control berries.

Exploring Intraspecies Diversity: A Comparative Genomic Study of *Metarhizium Brunneum* Strains V275 and ARSEF 4556

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Numerous fungal families include species capable of infecting and killing various invertebrates, with over 750 entomopathogenic fungal (EPF) species described. This has led to growing interest in EPF as biological control agents, replacing chemical insecticides. The genus *Metarhizium*, particularly *M. brunneum* and *M. anisopliae*, plays a key role in global biological control. *Metarhizium brunneum* species, including M. *brunneum* strain V275, show dual life modes in nature as both entomopathogens and beneficial endophytes in plants, rendering them suitable candidates as biofertilisers and plant biostimulants. Until now, the increasing availability of *Metarhizium* genome sequences has revealed several secondary metabolites crucial for adaptation and interaction with hosts, highlighting the complexity and strong potential of these fungi for exploitation in IPM strategies. A comprehensive genome analysis of the entomopathogenic and endophytic fungal strain *Metarhizium brunneum* V275, comparing it with *M. brunneum* strain ARSEF 4556, is performed in this study. V275 has the largest genome among all known *M. brunneum* strains, characterized by a high gene order conservation and unique genome fragments, suggesting a dynamic genomic organization. Phylogenetic analysis and mating type gene composition reveal that V275 diverges significantly from other strains, with its larger genome indicating possible horizontal gene transfer (HGT) events. Genes linked to its dual lifestyle, including those involved in plant cell wall degradation and insect pathogenesis, highlight its complex ecological roles. Notably, unique V275 genes suggest its potential to enhance plant stress tolerance. The presence of transposable elements (TEs) significantly impacts genomic diversity, suggesting TEs are major genetic variation and adaptation drivers. The analysis also identifies biosynthetic gene clusters (BGCs) for known and novel metabolites, indicating potential roles in endophytism and pathogenicity. This study enhances the understanding of *M. brunneum*'s genomic features, offering insights into its dual lifestyle, emphasizing the importance of further research on strain-specific genes and secondary metabolite production to comprehend the genetic basis of its ecological interactions and adaptation mechanisms.

Biopesticide-Driven Aflatoxin Control in Pakistan

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Aflatoxin, a highly carcinogenic secondary metabolite, has posed a persistent threat to both human health and animal welfare since its discovery in the early 1960s. With dual consequences, it not only adversely affects the health of living organisms but also leads to significant economic losses through the rejection of shipments that exceed permissible aflatoxin limits. Over the past two decades, Pakistan has grappled with this issue, experiencing hundreds of rejected consignments across various commodities, including chili, rice, spices, groundnut, and more recently, sesame. Despite the implementation of various mitigation strategies, satisfactory results have remained elusive. One of the most promising aflatoxin control measures involves the use of atoxigenic strains, a method successfully employed in regions such as the USA and African countries. In Pakistan, an atoxigenic strain was isolated from Maize soil, leading to the development of a bio-pesticide known as AflaPak^{TM} ($PKMNO_3$ genotype). Field trials were conducted across twenty-nine fields in five districts of Punjab province during both the spring and autumn seasons. Following recommended protocols, the bio-pesticide was applied, and samples were collected and analyzed at the Aflatoxin Bio-control Laboratory at the Crop Diseases Research Institute, NARC, Islamabad. *Aspergillus* strains (L and S) ratios and aflatoxin contents were determined in samples collected from treated and untreated fields, with the presence or absence of the $PKMNO_3$ genotype confirmed through multiplex PCR to validate the reduction of aflatoxin contents in treated samples due to bio-pesticide. Results demonstrated a remarkable up to 80% reduction in aflatoxin content in treated fields compared to untreated ones. Notably, out of twenty-four treated fields, aflatoxin concentrations fell within permissible limits (ranging from 2.3ppb to 18.6ppb) in nineteen fields, while the presence of the $PKMNO_3$ genotype—a key indicator of aflatoxin reduction due to bio-pesticide—was confirmed in sixteen treated fields, ranging from 16% to 100%. Given Pakistan's diverse climate and distinct agroecological zones, further research is warranted to identify atoxigenic strains from all zones and assess their efficacy, particularly for crop-specific bio-pesticides. Successful results in maize due to the use of the bio-pesticide have prompted the identification of atoxigenic strains from the chili crop, with ongoing optimization of the bio-pesticide in chili crop cultivation. These findings underscore the potential of employing bio-pesticides as an effective strategy to control aflatoxin contamination in various crops, thereby enhancing both public health and export opportunities in Pakistan.

Biopesticide Testing – The Challenges of Fitting in with Regulations and Guidance Designed for Synthetic Agrochemical Products

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The term biopesticide is used to describe a wide array of plant protection products based on biological organisms or the natural chemicals they produce. The increased use of biopesticides, both independently and as part of integrated pest management programmes, will be vital to achieving the stated aims of the EU's Farm to Fork strategy – reducing agrochemical use by 50% by 2030. Under current EU and GB law (Regulation No. 1107/2009), biopesticides are regulated along with synthetic agrochemical products under the same regulatory system – a system designed to ensure that only safe and effective plant protection products are permitted to enter the market. The data requirements under this system are extensive with rigorous testing required. Biopesticides can operate differently and are often more complex than synthetic pesticides. This presents a challenge to manufacturers bound by guidance documents and laws predominantly designed to assess more traditional synthetic pesticides. However, these challenges can be met with careful study design and open dialog with authorities.

The Holistic Approach of Controlling Fall Armyworm (Faw) with *Metarhizium Rileyi* in Zambia

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The PlantwisePlus programme is working towards empowering women and men smallholder farmers to manage evolving plant health threats, increase their incomes, improve food security and safety, and reduce biodiversity loss, through the promotion of sustainable crop protection practices. One aspect of this goal is promoting the use of biological control in favour of chemical pesticides. In Zambia, a naturally occurring fungus, *Metarhizium rileyi*, has been found to infect fall armyworm (*Spodoptera frugiperda*) larvae. CABI and ZARI (Zambia Agricultural Research Institute) are working on developing this fungus, potentially, into a biological control agent for use in Zambia. Laboratory bioassays have shown that the fungus is effective against FAW larvae, especially the younger instars. Various aspects of development are under way: 1) Molecular work has enabled detection of the fungal isolate to ensure that the isolate applied to the field can be identified, 2) Formulation development to ensure the fungus can be delivered to the FAW, 3) Mass production of the isolate and 4) discussing biocontrol with the local farmers. All these aspects are important in the conceptualization of biopesticide development.

Current Status of Integrated Pest Management of Thrips on Blueberry Crops in Morocco

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Currently, the red fruits crops are widely cultivated and considered as a booming sector in Morocco. In addition to strawberries, other species were introduced. The most cultivated red fruits in the Souss-Massa region (Southwest of Morocco) are raspberry, blueberry and blackberry. More than 90% of the production of blueberry and raspberry is mainly exported. During a survey conducted from 2020 to 2022, the main cultivated blueberry variety was DrisBlueNineteen (Corrina), but currently, Sekoya is becoming the dominant variety in the Southwest of Morocco. The thrips is one of the key pests of blueberry causing damages both on leaves and fruits. The gall midge (*Dasineura oxycoccana*) and spotted wing drosophila are also, important due to their significant impact. For thrips, there is limited information about existing species because growers may consider their bioecology and control strategies to be relatively similar. For chemical control only 2 active ingredients are approved to control thrips on blueberry (Pyrethrins and Azadirachtin) but other insecticides authorized on blueberry would control thrips when they are sprayed to control spotted wing drosophila such as Spinetoram. The monitoring of thrips (adults and immatures), their associated damages and released natural enemies is the key component of adopted strategy for control in the blueberry crops in the Souss-Massa area. The common method adopted for the pest monitoring is tapping buds and flowers rather than sticky traps. The blue sticky traps rolls are used generally as a mass trapping control method. The commonly used natural enemies were *Amblyseius cucumeris* and *Orius leavigatus,* with initial ratios starting from 250 and 0,25 individuals per square meter, respectively. These applications were repeated 3 to 4 times. These two thrips predators can feed on pollen as an alternative nutrient source. Therefore, *Lobularia maritima* was the most associated plant used to enhance predators' establishment and attract thrips in blueberry crops. The push-pull strategy using repulsive products and pheromones is currently in its early stages in this area of Morocco. Since the IPM strategy can be labour-intensive, the current focus is directed to set up and estimate the real economic threshold and economic injury level in order to optimize the technical aspects of the thrips control at a cost-effective approach.

The Application and Integration of *Metarhizium Brunneum* Strain Ma43 in Commercial IPM Programmes

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Bryan Limerick is the National Sales Manager at Lallemand Plant Care for the UK and Ireland.
Lallemand Plant Care is focused on exploring plant-microorganism interactions and developing innovative solutions to enhance plant health and productivity. Through collaborations with leading universities and research centres worldwide, as well as in-house research efforts, Lallemand Plant Care strives to positively influence specific microbial ecosystems to provide growers with profitable, sustainable and market-driven solutions. Bryan will be discussing applications of Lallemand Plant Care's *Metarhizium brunneum* products throughout UK and Europe, showcasing some grower experiences and results of product integration in commercial IPM programmes.

Current and Future Threats to Apiculture and Bee Health

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The western honeybee (*Apis mellifera*) suffers from many pests and diseases, and global honeybee colony losses remain high. The most serious pest remains the varroa mite (*Varroa destructor*), but other exotic threats loom, notably the yellow legged Asian hornet *Vespa velutina*, which was been frequently sighted in the UK in 2023, and sadly, may now be established in the southeast of England. Other threats include the small hive beetle *Aethina tumida*, which is established in Italy, and the *Tropilaelaps* mite, which is spreading from Asia into troubled areas such as southern Russia, Uzbekistan and possibly Ukraine. I will discuss how conventional chemical control of varroa has led to mite resistance problems and discuss how IPM approaches will play an increasingly important role in the control of most of these pests.

Apivectoring of Entomopathogen, *Beauveria Bassiana* Strain GHA for Suppression of Thrips on Commercial Greenhouse Strawberries: A Real-Life Study

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The cultivation of strawberries within greenhouse environments is an increasingly common area of agricultural productivity, affording consistent fruit production of an otherwise highly seasonal crop. However, due to its relative novelty, few management tools have been identified, assessed or registered to date for control of the many known pests of greenhouse grown strawberry crops. This includes evaluation of biocontrol strategies such as apivectoring, whereby microbial agents known to suppress crop pests are dispersed by commercially available pollinating bumblebees, Bombus impatiens (Cresson 1863) (Hymenoptera: Apidae). Towards addressing the need for such tools, this study evaluated the impacts of three periods of apivectoring in a commercial greenhouse strawberry production facility to determine how well the conidia of entomopathogen, Beauveria bassiana (Bals.-Criv. Vuill 1912), would be disseminated for control of crop pests such as the western flower thrips, Frankliniella occidentalis (Pergrande) (Thysanoptera: Thripidae). Our results indicate that bumblebees effectively dispersed a formulation of *B. bassiana* throughout the greenhouse crop, with the entomopathogen being detected on multiple flowers, leaves, and fruit. Furthermore, the impact of this tool on the quality of fruit produced, as well as possible adverse effects of the entomopathogen on carrier bumblebees were also evaluated. The *B. bassiana* formulation had minimal impacts on bumblebee populations, with under 16% mortality attributed to infection by *B. bassiana*. Through population monitoring, we found that naturally occurring thrips were being suppressed by the apivectoring biocontrol strategy, with up to 75% of Frankliniella occidentalis collected from some treatment zones testing positive for infection by *B. bassiana*.

The BPPRC Databases and their Utility for Pest Control Planning

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The Bacterial Pesticidal Protein Resource Center (BPPRC) is a web-based resource established in 2019 with a number of aims: to collate relevant information on invertebrate-active protein toxins from bacterial sources; to rationalise the nomenclature of these proteins; to provide an automated naming server for new submissions; to establish open-access databases for the sequences, structures and target specificities of the proteins. The latter database, in particular, has value in the selection of appropriate proteins for the control of specific pests and to establish history of safe usage when considering new products. The BPPRC, therefore, provides value to academic labs, industrial partners, regulators and end users. In this presentation, cross sectional data from the specificity database will be used to illustrate the breadth and utility of the data and highlight the range of insecticidal proteins that are produced by bacteria.

Catmint Essential Oil as a Feedstock for a Range of Insect Control Products

David Hallahan

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Entomol Products is a US-based startup, commercializing a natural-product insect repellent derived from the essential oil of the catmint plant, Nepeta cataria. Entomol is fortunate to have recruited a network of catmint growers that provides us with a high-quality, biological feedstock that can be developed into a range of repellent and beneficial attractant products. Our first on-skin repellent product, US EPA approved, became available in 2024. We have also demonstrated spatial repellency against mosquitoes, which will be the basis of a commercial offering in the future. The active ingredient in these products is the dihydronepetalactone molecule, which is enriched in the catmint essential oil by hydrogenation of its precursor, nepetalactone. Nepetalactone itself is a constituent of aphid sex pheromones and has been shown to attract aphid predators and parasitoids. I will summarize catmint oil processing and the range of applications that this versatile material may be applied to.

Innovative Approaches to Hive Health: Bee Vectoring and the Protectabee® for *Varroa a*nd Disease Management

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Varroasis is a major challenge in the honeybee industry, leading to significant annual losses. Innovative methods to combat varroa mites and other pests and diseases are essential for the industry's success. We have developed a novel approach to improve hive health through bee vectoring, which enables the introduction of beneficial health products into beehives without the need to open the hive. The ProtectaBEE®, an all-in-one hive entrance, allows beekeepers to easily add products at the hive's front, utilizing the activity of incoming foragers to distribute these products throughout the hive. This design also supports other varroa and disease management strategies, including the delivery of antibiotics for American and European Foulbrood, and long-term oxalic acid release and pest strips for varroa mite control. Our investigation into the ProtectaBEE® system heralds a transformative advancement in apiculture, offering a holistic solution to the challenges of hive management. By enabling passive, non-invasive treatment delivery, the ProtectaBEE® system simplifies beekeeping operations and provides substantial economic and practical benefits, paving the way for future innovations to enhance bee health and sustainability.

Evaluation of three strains of *Metarhizium brunneum* Petch for the control of *Halyomorpha halys* (Stål) adults

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Halyomorpha halys (Stal) (Hemiptera: Pentatomidae), commonly referred to as the brown marmorated stink bug (BMSB), is an invasive species that was first identified in Spain in the province of Girona (Catalonia) in 2016. It lives in a variety of habitats (urban, natural, and agricultural), requiring the use of various methods to manage its large populations. Two laboratory tests were carried out to assess the efficacy of three strains of the entomopathogenic fungi *Metarhizium brunneum* Petch (Hypocreales: Clavicipitaceae) in killing adult BMSB. In the IRTA entomology laboratory at the Mas Badia Center, insects were reared in cages with unlimited access to water and food at ambient temperature. Swansea University's Department of Bioscience provided strains V275, A3297, and A456 of *M. brunneum*, which were cultivated on Sabouraud Dextrose Agar (SDA) at IRTA in the Fruitcentre postharvest program laboratory. Conidia from SDA Petri dishes of each strain were suspended in 100 mL of sterile water amended with Tween 80 (0.03%) to achieve a final concentration of 3 x10^8 con/mL. Each solution was homogenized at 150 rpm for two hours and then used to treat 40 BMSB adults, with the same number of insects treated with water serving as a control. Adults were individually isolated in cells with free access to water and food and incubated in a chamber at 25 °C. Mortality was assessed at 1, 2-, 7-, 11- and 18-days post-treatment, and adjusted mortality was determined using the Abbot equation. A second test was conducted, following the previously described procedure but spraying the insects with a sublethal dose (0.002%) of lambda-cihalotrin before applying the fungal strain solution. The results showed that in the first test, strain A456 killed 100% of the insects after 7 days of treatment, strain A3297 showed the same results but after 18 days, and strain V275 killed 89.29% of the individuals at the last assessment. When a sublethal dose of insecticide was previously used, strains A3297 and V275 killed 100% of the insects within 7 days, while A456 killed 97.14% of the insects in the same time frame. The significance of the findings for insect control is discussed, and the next steps in the study of entomopathogens for *H. halys* control are identified.

Keywords: *Halyomorpha halys*, BMSB, Metarhizium *brunneum*, biocontrol, entomopathogen

A Walk of 20 Years for Bumble Bee Health: From Risk Assessment of Pesticides Towards Entomovectoring for Enhanced Pollination and Biocontrol

Guy Smagghe

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In this paper, I describe the first efforts in the early 2000s with the design of standardized bioassays with use of micro-colonies to assess the risk to bumble bees (*Bombus terrestris*). Workers of *B. terrestris* are important pollinators of wildflowers and many crops in agriculture. In these tests, the workers were exposed to pesticides by exposure via contact or diet, and the resulting effects on worker survival and sublethal reproductive effects of the nest were measured. With the development of for instance the neonicotinoid insecticides, their behavior effects on pollination services could also be assessed with an optimized design wherein the workers needed to learn foraging for food. In continuation, I will describe the use of managed pollinators as disseminators of pollen and also biological control agents against plant pathogens. Examples in both open field and greenhouse settings are given to present the usefulness of this technology into more sustainable production systems and green agriculture.

The Potential of Microbial Biostimulants in Enhancing Arable Farming

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The agriculture sector faces the dual challenge of increasing productivity to feed the growing global population while ensuring sustainable farming practices. Fertilisers and pesticides have, traditionally, been powerful tools for growers and farmers to increase yield and overall productivity under both optimal and suboptimal conditions. Reliance on these synthetic inputs is, however, being reevaluated due to their environmental concerns. Technological innovations, particularly plant biostimulants, are emerging as promising, eco-friendly alternatives. Plant biostimulants are substances or microorganisms applied to plants to enhance nutrient efficiency, abiotic stress tolerance and crop quality. This study evaluated the potential of Converta, a microbial biostimulant, to reduce fertiliser requirements in winter wheat (cv. Skyfall) under commercial farming practices. Four treatments were tested: 1) Full rate of fertiliser with no Converta (Control), 2) Full rate of fertiliser with Converta. 3) 75% of full rate of fertiliser with Converta and 4) Half the full rate of fertiliser with Converta. Control plots received standard fertilisation at 220 kg/ha N, 80kg/ha P, and 75 kg/ha K, using Nitram (34.5% N) and polysulphate. Converta was applied at 6L/ha in two applications 1) within four weeks of planting and 2) at the stem elongation stage, with each application at 3L/ha in a spray volume of 1000L/ha using a 36m wide boom sprayer. Each treatment was replicated four times in a randomised complete block design with plot sizes of 18m x 100m. Grain yield and the yield related parameters were statistically similar between Converta treated and Control plots except for the mean number of grains per ear. On average, grain yield increased by 22.02% in Converta treated plots receiving the full rate of fertiliser and by 15.73% in those receiving 75% of the full rate compared to Control plots. These results demonstrate that Converta can reduce fertiliser requirements by up to 25% without yield loss, offering cost savings for farmers and mitigating environmental impact through reduced chemical runoff and soil degradation. Converta thus represents a valuable asset for environmentally conscious farmers, supporting sustainable agriculture. Further fieldwork this season is investigating Converta's role in enhancing the protein content of winter wheat (cv. Crusoe) with Aminomax. Additionally, the effectiveness of Converta and Yokosan biostimulants in controlling cabbage stem flea beetles in winter oilseed rape (cv. Acacia) is being assessed at various dose rates. Early indications suggest that both biostimulants can limit beetle activity in damaging the new growth following application compared to Control.

Keywords: Sustainable farming, biostimulants, microbe-based biostimulants, fertilisers, pesticides, agrochemicals, Converta, Yokosan, abiotic stresses, winter wheat, winter oilseed rape, cabbage stem flea beetles etc.

Combatting Pesticide Resistance in Insects Using Botanical Bio-Synergists

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Over 600 species of pests have developed some level of resistance to pesticides, rendering many products ineffective and reducing the options for pest management. With increasing restrictions on use and withdrawal of active ingredients, together with the decline in the rate of new insecticide discoveries, options need to be explored to extend the useful life of products currently available. Plant derived compounds have been shown to interfere with the activity of the enzymes that detoxify insecticides and are involved in metabolic resistance in insects. The use of such compounds will increase the efficiency of insecticides thereby reducing application rates and/or counteract metabolic resistance allowing effective control to be restored without increasing application rates. Botanicals have been tested in combination with selected plant protection products and efficacy compared to single product applications, using standard laboratory efficacy testing methods. Data shows that the efficacy of pyrethroids against the cabbage stem flea beetle (*Psylliodes chrysocephala*), which have developed resistance against this pesticide group, can be restored when used in combination with botanicals. Similarly, efficacy of Spinosad against cabbage root fly (*Delia* radicum) can be enhanced when used in combination with botanicals, reducing the amount of product required for effective control. Enzyme activity assays have also indicated that some of these botanicals are interfering with the function of certain enzyme groups that detoxify insecticides, which correlates with the mortality data from the bioassays. Botanicals may counteract the metabolic resistance of some insect pests and thereby restore efficacy and/or allow the reduction of pesticide required for effective control.

Challenges and Practicalities of Biopesticide Product Testing in Crops

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After confirming the activity of newly developed pesticides and agrochemicals against specific pests, their introduction into the UK market relies on the success of the registration process. This process evaluates the efficacy of active ingredients against targeted pests and ensures their safety for crops and the surrounding environment. The registration process follows extensive testing by several Chemical Registration Organisations across the UK, including i2L Research. The journey from identifying a suitable source of active ingredients to delivering the final product to farmers encompasses several stages: sourcing, extraction, formulation, mass production, lab and field testing, and distribution. Each step presents its own set of challenges.

i2L Research plays a crucial role in this process by verifying the efficacy and safety of products developed by R&D teams. We test pesticides on targeted crops and observe the challenges farmers may face during application. Additionally, we identify issues related to testing, registration, logistics, and technical aspects, among others. Using biologicals as sources of active ingredients for pesticides adds complexity at every stage, from R&D to application. This presentation addresses the specific challenges and practicalities involved in testing biopesticides to facilitate their registration and commercial use by farmers.

The Holistic Approach to Plant Disease Management

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Plants are a dynamic system of continually interacting organs that are also in continual interaction with the microbiomes housed within and around these structures and the macrobiota in their immediate environment. The nature of these interactions has been overlooked in agronomy, with a preference amongst growers for achieving a sterile plant. However, it's becoming increasingly obvious that this approach is counterproductive – not only does it create a vacuum that can be exploited by pathogens, but there are a wide range of benefits that fostering healthy microbiomes around the plant can deliver. By implementing a holistic approach, growers are able to use products that will manipulate the plant and its microbiome to undertake natural processes that will foster a thriving ecosystem of microbes. These communities improve the speed and strength of plant growth, increase resilience to disease, and reduce input costs – enabling growers to produce crops in a more environmentally and financially sustainable manner.

Sentinel Crop Disease Surveillance Network: A Novel Tool for Integrated Pest Management

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The Sentinel Crop Disease Surveillance Network is an innovative solution designed to enhance Integrated Pest Management (IPM) practices through advanced airborne pathogen detection. This UK Innovate-funded project focuses on developing sentinel sensors capable of detecting airborne spores as they enter a region or crop field. The sensors being developed use a specialized bio-film to stimulate spore germination, which is monitored by an AI-driven
camera system. This network of sensors provides real-time alerts, enabling farmers to apply
fungicides strategically and effectively, thus reducing unnecessary agrochemical use and
enhancing crop protection. Field trials conducted in 2022/2023 demonstrated the system's efficacy in monitoring yellow rust in wheat. The real-time data from the sensors informed the timing of fungicide applications, resulting in reduced disease incidence. The Sentinel system's vision is the integration of environmental sensors and wireless communication modules ensuring robust, autonomous operation, offering a sustainable and scalable IPM solutions. Additionally, we will review our recent publication, "Yellow Rust Infection of Wheat: How the Quantity of Light Received by Wheat Seedlings Before Inoculation Affects Infection Efficiency," highlights the crucial role of wheat volatile organic compounds (VOCs) in spore germination. Our findings indicate that VOCs collected from wheat subjected to high light intensity significantly enhanced spore germination, a key insight that underpins the Sentinel system's design. By understanding the environmental factors influencing pathogen development, we can further optimize the technologies behind the Sentinel sensors for early disease detection and improved IPM strategies.

Approaches to Manipulate the Insect Microbiota and Immunity to Enhance the Effectiveness of Entomopathogenic Fungi

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Insect bacterial associates are involved in the pathogenesis caused by entomopathogenic fungi (EPF) *Beauveria* and *Metarhizium*. The level of bacterial involvement causes two scenarios of mycosis: 1) rapid (acute) pathogenesis with fast mortality followed by bacterial decomposition of insects; 2) prolonged pathogenesis ending in conidiation on the cadavers. Using the model system Colorado potato beetle – EPF, we demonstrated that prolonged mycosis allows the host to activate the immune-signaling pathways related to the antibacterial defenses. Conversely, during acute pathogenesis, the host's resources are insufficient to fully activate antibacterial reactions, and this situation gives a competitive advantage to bacteria thereby leading to rapid death. The application of different immunesupressors, such as avermectins, the toxins of *Bacillus thuringiensis*, and plant insecticidal metabolites in combination with EPF increases the bacterial load in insect tissues and shifts the development of mycosis to the acute scenario. Similar effects were registered for the mosquito *Aedes aegypti* and the wax moth *Galleria mellonella*. Thus, the suppression of the antibacterial host's systems allows a reduction in the lethal time and an increase in the effectiveness of the products based on EPF. The study was supported by Russian Science Foundation (No. 22-14-00309).

Integrated Pest Management in Forest Nurseries – Opportunities and Challenges

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The UK forest nursery sector produces around 160 million forest usable saplings for planting across the nation. With increased focus on tree planting and their potential role in meeting climate change targets, maximising production outputs through careful management of crops and pest & disease management is essential to meet sector demands on plant supply. There is a large range of pest and diseases that present issues for forest nurseries, including Lepidoptera, Curculionidae, Aphididae, as well as a host of fungal and bacterial pathogens. There are a range of challenges converging that restrict business as usual ways of working, including climate change, changes to pesticide approvals, and increased complexity of nursery growing systems. To innovate production, new ways of thinking will be necessary. Integrated Pest Management (IPM) has been applied to varying degrees in forest nurseries for years, however developments in the field of bio-controls and associated technologies bring about exciting opportunities to reshape how pest management is applied in forest nurseries. Plant and Seed Supply, Forestry England, is responsible for overseeing the production of 7.5 million forest usable cell-grown and bareroot plants per year, and additionally the unit manages 12 seed orchards as well as various seed stands across the country. Development and implementation of robust IPM strategies has been key to optimise production and manage pests in the various work streams. Monitoring activities have been crucial to gather data and inform action thresholds and plans. Positive results have already been achieved incorporating a range of beneficial predators into the preventative pest & disease programmes, including entomopathogenic nematodes, predatory spider mites and wasps. Linking up with the wider IPM sector could vastly improve the uptake and understanding of IPM in forest nurseries.

Pherosyn's Technology Breaks Open the Marketplace to More Chemically Complex Pheromone Monitoring Tools

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Nature identical insect pheromones are an important component of organic and conventional framing practices and can be used to monitor and control pest populations while protecting the earth's biodiversity. The specificity of pheromones allows direct targeting of pests which is especially important in reducing crop inputs and slowing down the rate of pesticide resistance that is currently being observed around the world. By employing biomimicry approaches using volatile synthetic insect pheromone lures, farmers and growers can monitor pest pressures over time, and be alerted to when the level of infestation breaches a critical economic threshold of damage. For lepidopteran (moth) species this is fairly common practice, however many other pests use far more complex structured pheromones, and the use of standard IPM tools such as monitoring traps has been elusive. Currently farmers have very limited tools to assist in the timing of application of pest control products; a situation that needs to change fast. Using innovations acquired from many years of synthetic chemistry research, scientists at PheroSyn have used their technology to make complex structured pheromones. Here were show commercial field data from monitoring traps containing complex pheromones such as those used by the pea midge *Contarinia pisi*, an important pest for vining pea and fava bean producers in the UK and elsewhere. This study shows the impact that tools have on crop yields, providing an opportunity to open up the pheromone field to many more species of pests than has previously been explored. PheroSyn's core mission is to reduce the use of chemical pesticides and in turn help reverse the horrendous decline in biodiversity currently seen globally. By employing innovative technologies to reduce the cost of production of chemically identical insect pheromones, PheroSyn is developing a portfolio of interesting monitoring products.

Discovery and Screening of Novel Bacteria, their Sonicates and their Solvent Extracts Against *Culex Pipiens Molestus* Larvae

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Mosquito transmitted disease kills over 700,000 people each year. Availability and efficacy of traditional insecticides continues to decline, driving the search for environmentally friendly alternatives. Disparate habitats in Crete were surveyed extensively and 797 live bacterial isolates were coarsely screened against 4th instar *Culex pipiens* larvae, of which 39 caused LT100 values <3 days. These 39 were assessed intensively using 10 mL of sonicated liquid cultures in 90 mL distilled water containing 10 *Cx. pipiens* larvae (n = 90). Liquid cultures of the 39 were also extracted into hexane and ethyl acetate and re-assayed in parallel to gain insights into the relevant metabolite characteristics. Several bacterial isolates showed potent larvicidal activity, with four key species - belonging to the genera *Pseudomonas* and *Chryseobacterium* - demonstrating significant potential for biopesticide development, achieving LT100 in as little as 24 hours. Solvent extract assays showed that non-polar extractions contained the majority of larvicidal actives, but not for all isolates, while pupation delay was found to be common in polar extracts. Data show that several species of terrestrial bacteria from the island of Crete, alongside their specific metabolites, are highly promising candidates for future development as novel biopesticidal agents.

Possibilities of Controlling the Oak Lace Bug with the Entomopathogenic Fungus *Beauveria Pseudobassiana i*n Forests

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The Oak Lace Bug, *Corythucha arcuata* (Heteroptera, Tingidae), is an oak pest originating from North America, which appeared as an invasive species in the most important oak forests in the eastern part of Croatia in 2013. It became clear that it had adapted to new conditions and that, given the lack of natural enemies, it would spread to other oak forests, primarily towards the west. Premature yellowing and falling leaves raised many questions not only from forestry experts but also from the public. Considering that this pest spends most of its life on the underside of the leaf, which is difficult to reach with conventional methods (e.g., spraying insecticides from airplanes), control measures proved to be problematic from the very beginning. Insecticides have been unsuccessfully used in the forests of Croatia on several occasions by air treatment, and the effects were more harmful than beneficial. The discovery of a Croatia's natural strain of the entomopathogenic fungus *Beauveria pseudobassiana* (BP) in 2020 opened the possibility for researching this organism to assess its potential for possible use in the field. Optimum spore concentrations, mass production of spores, doses, ways and places of application, as well as effects on different insects' developmental stages and impact on non-target species (especially natural enemies), were investigated. The research conducted between 2020 and 2023 has confirmed that the entomopathogenic fungus BP is naturally present in forests, indicating the existence of an inoculum that represents a link in the regulation of populations of this invasive insect. Moss at the bottom of trees was identified as a winter habitat of Oak Lace Bug adults and proved to be the weakest link of the pest. By treating moss with the Bp preparation, the natural inoculum was increased. At the same time, there was no influence on spiders or mites in moss. Additionally, the study of Colony Forming Units around the threatened trees showed a decrease during the year, similar to naturally occurring colonies.
According to the results of this research, Bp shows great potential as a biological control agent, but further research is needed to recommend methodologies and application technologies, as well as registration methods for the agent. Over the course of three years of experimentation, various methods, approaches, and application technologies of the agent were tested, with some showing promising results.

Keywords: *Corythucha arcuata*, invasive pest, moss, oak forests, Colony Forming Units, natural inoculum.

Red Palm Weevil Plant Derived Attractants and Repellents

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The red palm weevil (RPW, *Rhynchophorus ferrugineus*) is a highly destructive pest of palm trees which has spread from Southeast Asia to many other parts of the world. Behaviour modifying chemicals (semiochemicals) are recognised as playing a major role in management of RPW populations. Attractants can be used for monitoring, mass trapping and in "lure and kill" pest control programmes. Repellents can help deter oviposition and feeding damage by adult weevils. Both attractants and repellents could also be used in "push-pull" pest control programmes. The current paper reports on a study using a combination of olfactometry and in silico approaches to identify candidate attractants and repellents. Male and female RPW differed in their responses. For example, female RPW responded strongly to: α-pinene and cymene but not myrcene and thymol. In silico studies revealed the affinity of the screened compounds to odour binding proteins and receptors in both male and female insects. The significance of these findings as regards development of RPW semiochemicals is discussed.

UV-Mediated Immune Response and Interference with Integrated Pest Management Strategies

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Ultraviolet (UV) radiation significantly impacts living organisms and has been utilized in agriculture, particularly in pest control, for some time. Recently, UV radiation has gained recognition as a potential tool for immunosuppression in insect populations, offering a novel approach to pest management. Our research focuses on understanding how UV radiation can impair critical immune pathways in insects, which are often involved in resistance mechanisms. *Plutella xylostella*, *Bemisia tabaci*, and *Nilaparvata lugens* are significant pests that have developed resistance to various synthetic insecticides, making them difficult to manage. In our studies, we combined different UV radiation types with various pest management tactics. We found that UV radiation can cause significant oxidative stress and disrupt detoxification enzyme activity, which could be leveraged to control insect pest populations more effectively. For example, exposing *P. xylostella* to UV-C radiation enhanced the virulence of the entomopathogenic fungus *Cordyceps fumosorosea*. Similarly, UV-A exposure not only delayed the developmental time and reduced the fecundity of *B. tabaci* but also disrupted enzyme activity, favoring the efficacy of entomopathogenic fungi and parasitism by *Encarsia formosa*. Our research also revealed that these changes in developmental time, fecundity reduction, and enzyme activity are associated with alterations in gene expression. Additionally, when *N. lugens* was exposed to UV-A, UV-B, and UV-C radiation, we observed downregulation of several immunity-related differentially expressed genes (DEGs). This downregulation led to suppressed insecticide resistance in *N. lugens* against various neonicotinoid insecticides, with UV-C having a particularly significant impact. These findings highlight the potential of utilizing specific UV wavelengths to manage insecticide resistance. However, it is essential for future studies to explore the broader ecological implications, including the effects of UV radiation on host plants, and to strategically select optimal UV wavelengths to achieve desired outcomes.

Is *Metarhizium Brunneum* Ovicidal Against Grey Field Slug (*Deroceras Reticulatum*) Eggs?

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The grey field slug (*Doroceras reticulatum*) is an economically important crop pest, costing farmers yield loses of over £100 million annually. Major effective molluscicides used to control the pests have been withdrawn, hence there is a pressing need to explore other sustainable alternatives. *Metarhizium brunneum*, an entomopathogenic fungus has been demonstrated to convey bio-pesticidal effects on key invertebrate pests thus has potential to contribute to sustainable pest management. However, its effectiveness as an ovicide on slug eggs is not known. This study assesses the use of *M. brunneum* as bio-ovicide against the grey field slug eggs. Two strains of the fungus, -A4556 and V275, were inoculated onto freshly laid slug eggs using water-based and oil-based delivery techniques. Our findings indicated that water-based delivery of the inoculum had no significant impact on slug eggs when compared to the control group. However, when the inoculum was delivered with an oil-based carrier, the fungi infected the eggs of slug, but hatch rates did not differ from the oil-carrier control, suggesting that the oil carrier itself caused the egg mortality. We conclude that the entomopathogenic fungi did not exhibit inherent ovicidal properties. Moving forward, our research will investigate the effects of these fungi on the various juvenile stages of slugs to better understand their potential role in integrated pest management.

Keywords: Entomopathogen; *Metarhizium brunneum*; fungi; biological control; *Doroceras reticulatum*

Some Aspects of Survival and Infectious Diseases of the Colorado Potato Beetle During Hibernation: Prospects for Forecasting and Population Control

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In temperate latitudes, the overwintering period of the Colorado potato beetle (CBB) can reach 9 months. This period is the most critical in the insect's life cycle in terms of survival. A high percentage of the insect mortality is observed during this period. However, different aspects of overwintering and the causes of the CPB winter mortality still remain poorly understood. This is mainly due to the technical difficulties of obtaining a large number of beetles overwintering in natural conditions. In the field experiments with mesocosms, we developed a technique that allows obtaining the required number of overwintering in natural conditions CPB individuals at different periods of hibernation. During the overwintering period from September to May, with a sufficient level of snow cover (at least 30 cm) and maximum soil freezing to minus 8°C, the survival rate of the beetles was 62%. The insect mortality increased during overwintering and reached its highest values in Spring (April-May) as the soil thawed and warmed up. Among the cadavers with fungal infections, members of the *Beauveria* genus, particularly *B. pseudobassiana* (relatively psychrophilic) and less frequently *B. bassiana* (relatively thermophilic), were dominant. Bacteria belonging mainly to the genera *Serratia, Pseudomonas, Rahnella, Sphingobacterium, Microbacterium, Brucella* and *Rhodococcus* were isolated from the cadavers with signs of bacterial decomposition. Metagenomic analysis of the body contents of CPB cadavers with signs of bacterial decomposition revealed the predominance of *Rhodococcus, Photorhabdus*, and *Pseudomonas*. The presence of *Photorhabdus* in the microbiome may indicate infection by nematodes. We succeeded in isolating several presumed species of nematodes from the CPB bodies, one of which was identified as *Heterorhabditis megidis*. Analysis of several parameters of immunity in the tissues of overwintering beetles showed a decrease in the expression of genes involved in immune signaling pathways (Toll, IMD, Jak-STAT), as well as metalloproteinase inhibitors until April. A sharp increase in the expression of these genes was observed when the soil temperature increased to 10-14°C in May, coinciding with a 100-fold increase in the total bacterial DNA in the insects' gut during this period. The obtained data indicate that the spring transition to positive soil temperatures is a critical period for overwintering CPBs in terms of infection development and survival. Cultures of pathogens isolated from CPBs during overwintering may serve as a basis for the development of biological control agents targeting this pest.
This work was supported by the RFBR grant (No. 22-14-00309).

The Role of Semiochemicals in Lure and Kill Approaches for the Control Mosquitoes and Sandflies

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Attractive Targeted Sugar Baits – sometimes also referred to as Attractive Toxic Sugar Baits – constitute a novel additional tool in the fight against mosquito species that carry important diseases such as malaria, dengue and chikungunya. Mosquitoes require sugar meals as a source of energy in order to mate, oviposit and complete their life cycles. Unlike female mosquitoes, males do not require blood meals to complete their life cycle but they do require sugar for flight, swarm formation and mating. This they obtain as nectar from flowers, extrafloral nectaries, ripe fruits or from insect produced honeydew. The females of most species also require sugar but can also metabolise ingested blood for energy. ATSBs make use of this need for sugar by attracting mosquitoes to a bait that contains an oral killing agent, attracted to the bait by floral or fruit scents.

A talk on this subject given by the author at the New IPM symposium in 2023 described some of the work that has gone into the development of an ATSBs targeted at *Anopheles* malaria mosquitoes and currently undergoing epidemiological evaluation in several sub-Saharan countries. An update on this project will be given together with new work being done at Cardiff University to improve the attraction of mosquitoes to ATSBs.

Semiochemicals are also being developed for use in lure and kill techniques for sandflies which are important vectors of Leishmania parasites. An update on some of the work being done at Cardiff University in this area will also be given.

Automation and Digitization of the Data Collection and Processing in Honeybee Tunnel Tests to Enhance Introduction and Monitoring of Precise, Sustainable, and Less Intrusive Pest Management Practices for Flowering Crops

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Honeybee health is a critical component of integrated pest management (IPM), given their essential role in pollination and ecosystem balance. Honeybee tunnel tests, as outlined in the OECD 75 guidance document, are conducted under semi-field conditions to quantitatively assess the impact of plant protection products on honeybee colonies. The testing process involves the collection of extensive datasets encompassing behavioural, environmental, mortality and colony/brood development metrics. The data collection process is labour-intensive, carried out over discrete time intervals with biologically relevant gaps, demanding a high level of expertise from personnel, and susceptible to observer bias. Consequently, the complexity and costs involved in these tests often exclude them from practical use in assessing the effects of various IPM practices. Our project aims to enhance this process by developing a GLP-compliant technological solution that emphasizes data collection and processing automation through the integration of multiple measuring devices and sensors alongside the utilization of artificial intelligence for data processing and analysis.
Functional prototypes developed to date involve:
- A sensor embedded within the bee frame for direct and continuous monitoring of bee brood environmental conditions (temperature, relative humidity, sound frequency, and intensity).
- Environmental sensors within the bee tunnels to monitor temperature, humidity, and wind speed.
- A sensor at the hive entrance to track bee activity, electronically recording the ingress and egress of individual bees.
- Digital dead be trap that continuously monitors the number of bee corpses removed from the hive by worker bees
- A system for monitoring flight activity over flowering crops, utilizing AI to analyse images captured by a digital camera and identify individual bees.
- Digital scales for tracking the hive's total weight.
- Software for identifying brood developmental stages in images of the frames.
Data collected by these sensors are transmitted via IoT technology to cloud storage, accessible through a user-friendly graphical interface on mobile devices or PCs. The system provides real-time alerts for deviations from pre-set standard conditions through email or SMS notifications.
A GLP validation study is in process to compare digitally recorded data with traditional methods, utilizing multiple independent human observers for verification.

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Developing Products for Bedbug Control in a Realistic Test Environment

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The Common Bedbug (*Cimex lectularius* L.) has been making a global resurgence since the late 90s. They thrive in multiple occupancy buildings, where they easily move between rooms and apartments. The residual protection once afforded by sprayed liquid insecticides has now largely been lost due to insecticide resistance, leaving a gap in the tool kit of pest managers. Products with residual activity are particularly favoured for bedbug control, because bedbugs often hide in inaccessible locations, making them difficult to treat directly. In multiple occupancy buildings a lack of residual efficacy allows bedbugs to reinfest room that have already been treated, making it difficult to achieve building-wide control. The bedbug resurgence has driven a wave of innovation in bedbug products and services, which has in turn created a demand for live bedbugs for product development. Cimex Store Ltd was established to meet the growing demand for live bedbug specimens from universities, research labs and dog training schools, who use them for training bedbug detection dogs. In 2019 Cimex Store Ltd installed two test bedrooms to provide a realistic test environment for bedbug product development. The setup was initially used to develop iBug, a digital remote monitoring system for bedbugs. Since then, they have been used almost continuously to test a wide range of other bedbug products, including barrier tapes, pit fall traps, sticky traps, desiccant dusts, and sprays. The rooms are fitted with infra-red timelapse cameras for monitoring bed bug activity, which makes it possible to observe how bedbugs interact with monitoring devices. A live human host (the author - Naylor) sleeps in the rooms to elicit the natural bedbug foraging and aggregating behaviour. We have worked with inventors, academics, manufacturers, and pest managers to evaluate existing products and assist in developing new ones. Last year we completed an extensive study on Nattaro Safe, a diatomaceous earth-filled barrier tape, which was fitted to the underside of the bed frame. The tape caused an 86% reduction in the final bedbug population after 6 weeks, compared to the no-treatment control. This year we have been evaluating Aprehend (ConidioTec, USA), a suspension of entomopathogenic fungal spores, which can be applied to the bed frame and wall-floor junction. Bedbugs that cross the treated zones become infected with the fungal pathogen and typically die in about a week. The product is becoming popular in the USA and Canada, and Andermatt Biocontrol Suisse are hoping to make it available for UK/EU markets. The purpose of our study was to produce efficacy data for the biocidal product registration.

A Novel Mosquito Trap (Mataaedes) for the Control of Adult *Aedes* And *Culex* in Residences

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With one million notified cases of dengue over the first 2 months of 2024, many cities in Brazil have declared this an epidemic. This number is certainly an underestimate of the real situation, and sadly once again the current approaches used to control the mosquito population are failing. Therefore, new strategies need to be urgently implemented in a rational integrated vector management (IVM) program. One component of this IVM could be the application of entomopathogenic fungi (EPF), many of which are compatible with conventional methods. EPF can cause mortality following ingestion of inoculum (larvae ingesting fungal propagules) or by adhesion of propagules to the host cuticle, with subsequent cuticle penetration and colonization of the host's body. Here we will present the efficiency of EFP-impregnated traps that could be deployed for the reduction of adult mosquito populations. These traps were developed by the Universidade Estadual do Norte Fluminense (UENF) and the start-up MosquiTec Ltd. Oviposition traps (ovitraps) are lined with fungus-impregnated paper. Females become infected when landing to oviposit. The Mata*Aedes* (Kill*Aedes*) trap [https://www.mataaedes.com.br/] attracts both *Aedes* and *Culex* mosquitoes, and the volatiles released by the conidia also act as an attractant together with the dark internal surfaces of the trap. The traps were first validated in the laboratory (test cages and observation chambers), then in rooms simulating residential accommodations, and finally in volunteers' homes. The traps reduced adult survival in cages and test rooms by approximately 40%. In residences, the number of *Aedes* eggs was monitored using non-fungus-impregnated ovitraps. There was a significant reduction (>50%) in egg counts in the presence of Mata*Aedes* + EPF when compared to Mata*Aedes* without EPF. Similar results were obtained with fungus-impregnated ovitraps. These traps are cheap and efficient, killing mosquitoes without polluting the environment or negatively affecting the health of people exposed to these natural biological control agents. The traps could be deployed not only in residences but also in workplaces, schools, and hospitals. Commercialization now depends on registration by government agencies.

Effects of Endophytic Colonization of Tomato Plants (*Solanum Licopercicum*) by the Entomopathogenic Fungus, *Beauveria Bassiana*, on Phytotechnical and Productive Parameters in the Field

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Tomato, *Solanum lycopersicum* L., is a crop of worldwide commercial importance, but it faces serious phytosanitary challenges due to the high incidence of diseases and pests. There is a constant search for new methods of controlling and managing these problems. In this context, biological control using entomopathogenic fungi as endophytes is a promising alternative to conventional methods. This study carried out in the field, investigates the effects of inoculating tomato plants with the endophytic entomopathogenic fungus *Beauveria bassiana*, aiming to protect the crop against pests and to evaluate possible impacts on phytotechnical and productive parameters. Production parameters, such as fruit yield and quality, are currently under evaluation. The percentage of colonization via seed treatment with *B. bassiana* was studied. At 60 days post-treatment, colonization rates of 36% were recorded in the apical region, 20% in the stem region and 4% in the roots. At 90 days, colonization rates in the apical region were 27%, in the stem 8% and in the roots, continued with 4%. After 120 days in the field, the apical region had 21% colonization, while the stem and roots had 4%. At 30 days after planting in the field, significant increases were observed in the growth and development parameters of plants treated with *B. bassiana*, including plant height, number of leaves, number of branches, stem diameter and a reduced number of predated leaves. We are currently using metabolomics to understand the mechanisms involved in the interaction between the plant and the fungus, in addition to indicating how the endophytes act as agents to protect tomato plants against herbivorous insect pests.

Microbial Consortia in Agriculture – Using Nature's Biodiversity for Eco-Sustainability

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An agricultural microbial consortium can be considered as a group with two or more diverse microorganisms, that in combination, may produce plant beneficial effects for crop protection or production. Interest has intensified in recent years, in light of many updates in agricultural legislations, with reforms moving towards greener economies and practises to reduce the use of synthetic-chemical products to decrease environmental risks and improve consumer well-being by applying a one-health approach. The selection of a promising consortium cannot be casual but requires an in-depth scientific investigation of the individual components that is based on: their already known positive effects to the plant; a validation of their biological compatibility; the technological development of appropriate bioformulations to maintain microbial vitality and integrity; the testing of efficient application techniques in the field; and the evaluation of the biocontrol/biostimulant efficacy on a given crop. Nature has a biodiversity arsenal that can provide useful candidate microorganisms originating from the plant-soil microbiomes that include biological control agents (BCAs) for improved plant defence to pathogen or pest attacks, or biostimulants such as plant growth promotion (PGP) rhizobacteria or fungi to increase nutrient availability or plant uptake/assimilation. Possible opportunities to select the desirable consortium are to utilize practises to enhance the autochthonous beneficial populations in the agroecosystem or apply microbiological approaches to isolate and select potential microbes for biotechnological development. Noted plant protection products include diverse fungal antagonists such as *Trichoderma* spp. registered as biofungicides or isolates of *Beauveria bassiana* utilized as bioinsectides. Both fungal BCAs are also recognized for their abilities to function as inducers of plant systemic resistance and to act as PGP, thus enhancing crop yield and quality. Other studied microorganisms are comprised of PGP rhizobacteria belonging to *Bacillus* spp., *Azotobacter* spp. or *Azospirillum* spp. The challenge to produce successful biological products is to develop multi-purpose formulations, with good effective standards, that are user-friendly and able to confront the demanding requirements for an eco-sustainable alternative to chemicals. Such commercial products need to be readily integrated into existing farming systems, thus facilitating new advancements for a revolution of science and technology in modern agriculture.

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Development of Synergistic Microbial Consortia: An Element Key at the Modern Crop Protection

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A microbial consortium is a group of two or more symbiotic microorganisms capable of surviving under diverse conditions by the formation of synergistic population structures such as stromatolites, microbial mats, biofilms, etc. The microbial consortium is an ecofriendly technique that had a beneficial effect on soil health and soil fertility. For the selection of microorganisms, the desirable characteristics must be met with inoculant strains such as extended shelf life, survival capability under harsh conditions, cost effectiveness, efficient delivery with the host plant, genetic stability, physiologically adaptable with the host environment, etc. For potash biofertilizer, the selection of isolates should be based on their potassium-solubilizing capability with some other plant growth promoting (PGP) activities. Microbial communities are underutilized for insect control, partly due to challenges in optimizing environmental conditions and lack of understanding of complex microbial interactions. As these interactions are better elucidated and conditions optimized, further exploitation of microbial consortia becomes possible for the use in the crop protection. Both natural and engineered consortia will play a key role in emerging technologies, particularly in revealing factors associated with improving consortia stability and productivity at the crop protection.

Novel Biological Solutions for Pests and Diseases on UK Farms

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This poster details two projects funded by UK Research and Innovation (UKRI) which are both looking at novel, biological solutions for some key pests and diseases in UK arable farming. The two projects are in their second of two years and bring together partners that span biopesticide research, product commercialisation and farmer advisory services. The first project is focussed on control of the English grain aphid (*Sitobion avenae*), the Bird cherry-oat aphid (*Rhopalosiphum padi*) and *Septoria*, in wheat. This project is looking at fungi isolated from UK-soils and investigating whether any of the fungal isolates have both insecticidal and fungicidal activity; in-effect whether a single fungus could be used as a dual-action biopesticide. The second project is looking at a number of biopesticides, both commercialised and prototype preparations, to build a suite of potential controls in UK legumes. This project is targeting the Pea and bean weevil (*Sitona lineatus*) and foot rot pathogens; as well as looking at growth promotion of legumes when under drought stress. The biopesticides include microorganisms and natural substances. Both projects started in the lab, screening against the target pests and diseases and have recently moved into glasshouse trials (for aphids/*Septoria*) and into field-settings (for the legumes). The projects, combined, bring together CABI, the UK Agri-Tech Centre, FA-Bio, Agrii, Russell Bio, Fargro and the University of Warwick.

Precision Orchard Management for the Environment (Pome): Developing Commercially Viable Systems for Sensing and Applying Orchard Inputs

Tim Lacey

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Led by Hutchinsons, and part-funded by commercial partners, Innovate UK and DEFRA, the four-year, £4.5m Precision Orchard Management for the Environment (POME) project is using cutting-edge technology to digitally examine fruit trees in fine detail, allowing inputs to be targeted in a way that has never been seen before in UK orchards. The approach will use digital orchard scanning to generate precision dosing maps for blossom and fruit thinning, fertiliser application, growth regulators, pest control, and fungicides, as well as provide more accurate yield forecasting for growers. Hyperspectral imagery, NDVI and LIDAR will be collected from tractors, nocturnal robots and drones and will be combined using machine learning techniques to generate user-friendly maps that highlight target areas and can be used to generate application maps for variable crop inputs. The ultimate aim of the POME project is to reduce the environmental impact of tree fruit production by using fewer inputs, while simultaneously increasing orchard production efficiency, output and profitability through increased yield and grade-out.

Project partners include N.P. Seymour, The Acclaimed Software Company, Avalon Fresh, Outfield Antobot, Fotenix, NIAB East Malling, NIAB Cambridge, the University of Kent, Loughborough University, and the Health and Safety Executive's Chemicals Regulation Division (CRD).

Evaluating Commercial IPM Strategies for Sustainable Codling Moth (*Cydia Pomonella*) Control in Apples

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With the recent confirmed withdrawal of indoxacarb, and increasing pressure on remaining conventional insecticides, apple growers face an increasing challenge to manage lepidopteran pests – especially the damaging codling moth (*Cydia pomonella*). There are a number of alternative controls that are individually proven to work in managing codling moth but are yet to be adopted fully in mainstream orchards. To this end, a multi-year collaborative project has been established by Hutchinsons on commercial apple orchards in Kent to demonstrate the potential of using alternative control methods in an IPM approach for managing codling moth to commercially acceptable levels. Project partners Landseer Ltd. are providing automated codling moth monitoring using TrapView to time in-season applications of codling moth control products including Madex® Top (*Cydia pomonella* Granulovirus) from Andermatt UK. Applications of entomopathogenic nematodes in autumn from partner Koppert UK will be used to reduce over-wintering moth populations and in-season *Trichogramma* parasite use will also be investigated. Hutchinsons are providing the access to grower sites as well as agronomic input to the control strategies. The presentation will summarise the project aims and objectives and the progress to date within the first year of work.

First Year Experience of Lalguard M52 OD (*Metarhizium Brunneum* Strain Ma43) Foliar Bioinsecticide for Reduction of Soft-Bodied Pests in Commercial Crops

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A liquid formulation of *Metarhizium* for foliar applications has been long-awaited, following the established granular formulation (LALGUARD M52 GR) that is frequently incorporated into growing media for a number of ornamental and vegetable crops. In this first year of authorised use for LALGUARD M52 OD liquid formulation, Hutchinsons agronomy team report back on experiences from commercial use of the liquid formulation across a range of crops.

Metarhizium's Versatile Roles in Nature: Genomic Insights into Its Entomopathogenic and Endophytic Capabilities

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Fungi are lower eukaryotes known for their diverse modes of life, from saprophytism to parasitism, mutualism, and commensalism, presenting variable types of interactions with plants, animals, bacteria, and other microbes. The evolution of these lifestyles in fungi remains a significant question. With advancements in molecular genetics and genomics, it's evident that they possess genes enabling diverse lifestyles. An excellent example is the genus *Metarhizium*, known for its entomopathogenic species which are being used as Biological Control Agents to protect crops (e.g. *M. brunneum* strain V275, commercially known as Lalguard Met52). Studies have shown that *Metarhizium* can also colonize various plants, leading research towards the exploration of its metabolic pathways and genes involved in endophytism for potential use as biofertilizers and biostimulants. Whole Genome Sequencing (WGS) and analysis of two *Metarhizium brunneum* strains, including strain V275, using Nanopore and Illumina reads, revealed significant genome size variations. Comparative genomics with other *Metarhizium* strains identified plant-degrading enzymes, plant colonization-associated genes, and variations in secondary metabolic compounds and Transposable Elements. In specific, investigating the gene content and functions of *Metarhizium* species, particularly genes involved in secondary metabolism, provides insights concerning their versatile modes of life. Comparative genome analysis reveals that biosynthetic gene clusters (BGCs) and Protein Coding Genes (PCGs) in *Metarhizium* are categorized into common BGCs, scattered BGCs, and unique BGCs. Some PCGs crucial for metabolite production are shared among different BGCs. This suggests that plant host colonization might have preceded entomopathogenicity, supported by the presence of destruxins in both *Metarhizium* and phytopathogenic *Alternaria alternata*. Horizontal Gene Transfer events may also have facilitated *Metarhizium*'s adaptation to endophytism. These analyses enhance our understanding of EPF functionalities and their potential agricultural and ecological applications. Further in-depth studies are necessary to elucidate the evolutionary pathways and future lifestyle changes in fungi.

Rapid Detection of Mycotoxigenic *Aspergillu*s Spp. Associated with Pistachios Using Loop Mediated Isothermal Amplifications (Lamp)

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Aspergillus species create major postharvest problems due to the food losses caused by their mere presence and the hazardous mycotoxins they produce. The major mycotoxins associated with these species are aflatoxin B1 (AFB1), produced mainly by *A. flavus* and *A. parasiticus,* and ochratoxin A (OTA), produced mainly by *A. carbonarius*. In this study, we developed three rapid detection assays for the aforementioned species based on Loop-mediated isothermal amplification (LAMP). Three assays were developed targeting genes from mycotoxin production clusters, two of them are species-specific targeting genes *pks* and *aflT* for *A. carbonarius* and *A. flavus,* respectively. The third assay is generic to detect aflatoxigenic Aspergilli associated with pistachios including *A. flavus*, *A. parasitius* and *A. nomius*. Result visualization was done in real-time via detection of fluorescent signals. The method developed showed high sensitivity and specificity with detection limits of 0.3 pg/reaction of DNA for the *A. carbonariu*s assay and 0.03 pg/reaction for the other two assays. The assays were further implemented on inoculated nuts, including pistachios and almonds, after a one-step crude DNA extraction. These tests revealed a detection level of 0.5 spore/g that shows the effectiveness of LAMP as a rapid method for detecting potentially toxigenic *Aspergillus* spp. directly from food. The validation of the assays included tests on a larger scale that further confirmed their sensitivity and specificity, as well as enabled the production of ready-to-use LAMP kits. These kits are easy to use and aim to simplify the screening of food samples in order to monitor the presence of specific *Aspergillus* contaminations.

Electrochemical Sensor for Emerging Micropollutant Detection in Water or Capacitive Deionisation (Cdi) for Water Desalination and Treatment

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Approximately 90% of coffee grounds are wasted, creating hundreds of thousands of tonnes of waste coffee grounds (WCG) per year. This has made WCG one of the most abundant types of food waste that remains largely unexploited by industry. WCG contains a high volume of carbon, which can be first turned into porous and conductive carbon powder through a modified carbonisation process and then mass produced into electrodes via high-volume screen-printing technique. This upcycling approach of electrode fabrication from near zero-cost and toxic WCG can contribute to the long-term societal goal of circular economy. For example, these low-cost food waste derived carbon electrodes can be applied in many environmental technologies: 1) Capacitive deionisation (CDI): CDI is novel desalination technology, which can remove a range of heavy metal contaminants from water as well ; 2) Electrochemical sensor for emerging water contaminant detection: For water utility companies, typical process to analyse these emerging water contaminants takes several days, which requires the transportation of water samples to a lab, and is also expensive (e.g. few hundred pounds per sample) and labour intensive. WCG derived sensors can potentially reduce this time down to minutes and cost down to few pounds.

Entomopathogenic Fungi, *Beauveria Bassiana* and *Metarhizium Anisopliae,* as Endophyte Primed Immune Responses of Tomato Plant to Herbivory

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Plants have different defence mechanisms to protect themselves from biotic and abiotic stressors. In addition, some of these stressors can effectively prime plant defence responses and make them more resistant to herbivory. In this study, we examined the effects of two entomopathogenic fungi (EPFs), *Metarhizium anisopliae* strain F01 and *Beauveria bassiana* strain GHA, on priming plant defence mechanisms in tomato (*Solanum lycopersicum*). First, we examined the potential of our entomopathogenic fungal isolate for systematic growth in tomatoes from leaf tissue to other sites over time. We found that following the inoculation of tomatoes with these endophytic fungi, the growth of aerial and underground tissues of treated tomatoes was affected, and the total phenolic and flavonoid contents and DPPH scavenging activity changed in different tissues (leaves, stem, and root) over the time compared to the control. Both *B. bassiana* and *M. anisopliae* as endophyte in tomato can reduce the preference of *Tuta absoluta* in choice and no-choice experiment. In addition, *T. absoluta* developmental parameters decreased after rearing on tomatoes colonized by fungal endophytes. In this study, for the first time, we found that pre-inoculation with *B. bassiana* or *M. anisopliae* strongly induced *PR-10*, *ERF*, and *TGA* gene responses in the phytohormone pathways of tomatoes after *T. absoluta* attack compared to infested plants grown in the absence of the fungus. Also, in the phenylpropanoid pathway, *P450*, as well as other defence-related genes, *PRODH*, *nsLTP*, and *WIP*, were strongly induced in endophytically colonized tomatoes after *T. absoluta* herbivory compared to non-colonized tomatoes. These results indicate that EPFs as endophytes can effectively prime plant defence responses, making them more resistant to herbivory with faster and stronger reactions when the stress recurs. These findings provide useful information for understanding the mechanisms of *B. bassiana* and *M. anisopliae* in tomato plant growth promotion and quicker responses to *T. absoluta* attack by priming the immune response, which would facilitate further improvement of EPFs for use in plant production.

Keywords: endophyte, entomopathogenic fungi, immune response, tomato, tomato leaf miner.

The Need for Regulatory Reform in Europe and the UK

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Biopesticide Regulation in the EU currently offers little recognition or deviation from the technical requirements applied to traditional Plant Protection Products. Although publication of new guidance is helpful, overall compliance remains challenging. Understanding and acceptance by the Evaluators remains difficult and opportunities to enter the market overly burdensome. GB – whilst adopting EU Regulation 1107/2009 upon leaving the Bloc – is engaging with Industry to develop a more realistic approach. This presentation highlights key data points which require a more appropriate approach, from an applicant's view".

The Use of Endophytic Entomopathogenic Fungi for Improved Pest Management: A Chemical Ecology Perspective

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Entomopathogenic fungi are microorganisms which can naturally infect insect pests, and several strains have been developed as biocontrol agents. Increasing evidence shows that they can also adopt an endophytic lifestyle, providing plants with protection against pathogens and herbivores. To improve biocontrol efficacy, there is growing interest in combining biocontrol agents across different guilds, to determine their efficacy in the management of insect pests. Using a combination of analytical chemistry (Gas Chromatography (GC), coupled GC-Mass Spectrometry (GC-MS)), insect electrophysiology (GC-Electroantennography (GC-EAG)) and olfactometer bioassays, we investigated whether root inoculation of sweet pepper (*Capsicum annuum* L.) with the entomopathogenic fungal species *Akanthomyces muscarius* ARSEF 5128 and *Beauvaria bassiana* ARSEF 3097 can improve resistance against the tobacco peach aphid *Myzus persicae* var. *nicotianae*, and whether root inoculation is compatible with *Aphidius ervi* parasitoid wasps for improved aphid biocontrol. Aphids were significantly attracted to the odour of plants inoculated with *A. muscarius* over non-inoculated plants, although aphid longevity and fecundity were also significantly reduced when feeding on plants inoculated with *A. muscarius. A. ervi* was significantly attracted to the volatiles of *M. persicae*-infested *C. annuum* plants inoculated with *A. muscarius*, compared to non-inoculated, un-infested plants. In conclusion, endophytic colonization by entomopathogenic fungi has the potential to alter olfactory behaviour and performance of both *M. persicae* var. *nicotianae* and *A. ervi*. Findings here demonstrate the influence of using biological control agents from different guilds, which could be implemented into integrated pest management programs.

Sensor Swarms to Monitor Honey-Bee In-Hive Behaviour

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Advances in commercial, low-power computer technologies have enabled the development of economical beehive monitoring systems to measure and predict colony behaviour with practical applications in beekeeping and bee, ecological and environmental health.

Additional insights have been gained by placing sensors in close proximity to the bees to study behaviours such as the waggle-dance. Being able to sense in the way bees do (particularly using bioacoustics, biotremology and chemoreceptors) provides a clearer understanding of what triggers bee behaviour and their perceptual processes. This project aims to develop miniature, multi-sensor technologies applying and developing multiple threads of existing research at Swansea University (particularly integrated biosensor fabrication). By incorporating distributed intelligence to analyse and locate multi-modal sensors in close contact with the bees it is hoped that a more intimate understanding of individual and small-group bee behaviour and colony well-being can be acquired. This understanding might then be applied to utilise bees (and other organisms) as biosensors of the environment and ecology.

Self-organising swarms of sensors roaming the honey-bee environment (both inside and outside the hive) is a long-term, MASI-funded, project but, along the way, the practical application of solutions to some of the many problems encountered in the process can be developed as valuable applications in beekeeping for bee, apiary and wider ecological health.

Developing Integrated Solutions for Wireworm Management, in the Uk

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Wireworms (Coleoptera, Elateridae) are the larvae of click beetles and some, of the species in the UK are known to be serious plant pests and damage many crops including potatoes, cereals and vegetables. Most susceptible crops are damaged by plant loss, but potatoes suffer by loss of quality at populations as low as 10,000 per ha. Although one insecticide (fosthiazate) claims reduction of wireworm damage, but no insecticide available in Europe provides more than moderate control of damage.

A Cupgra review in 2022 identified improvements in risk assessment and bait trapping methods. Our knowledge of the species involved also needed updating. Losses were mounting and some growers were exiting potato production in the face of such losses.

Not all species of wireworms are crop pests, and more information is needed on some of these. The ability of agronomists to identify larvae was lacking and we have improved this with good knowledge exchange. Our recent work enables us to assess the risk, monitor and identify species involved, manage the problem in a rotation, and identify the susceptibility of potato varieties. A European Wireworm Research Network has recently been established and the first workshop was held in Oslo in July 2024.

Microbial Community to Mimic Woodland Soils – Fungi Bio-Fertiliser Innovation Work

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There is increasing concern in academia, industry and society, that agricultural and horticultural intensification is leading to large-scale ecosystem degradation, significant greenhouse gas emissions, and loss of crop, plants and tree productivity due to reduced soil health, pests and diseases. Long-term use of synthetic fertilisers weaken beneficial plant-microbe networks, specifically diversity and abundance of fungal communities. These fungal communities are critical players in maintaining soil ecosystems and are essential for decomposition of organic matter into crop nutrients.

Woodland Grow are developing a complex microbiome of over 5000 Bacteria and 1000 Fungi, including mycorrhizal species and 40% dark fungi with nutrient cycling microbes and natural sources of nutrition to grow crops, plants and trees. Examples of the benefits of healthy soils and diverse microbial communities include Oaks free from mildew and Hazels free from Aphids compared to control (peat free and synthetic fertiliser).

Formulation of i*n vivo* Produced Long Double-Stranded RNAfor Plant Protection

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Growing concerns over negative effects of pesticides on the environment and on human health are the cause of an increased demand for environmentally sustainable plant protection agents. A promising alternative to conventional chemical pesticides is double-stranded RNA, a nature-derived and environmentally safe molecule that occurs in all organisms and is rapidly degraded in soils. Its application triggers RNA-induced gene silencing, also known as RNA interference (RNAi), an ancient cellular mechanism of eukaryotic cells to protect themselves against pathogens, as well as a means of gene regulation.

In the project BioProtect, we are developing formulations for spray-induced gene silencing (SIGS) with long dsRNA produced in a bacterial host system. We formulated the dsRNA in interpolyelectrolyte complexes (IPECs) composed of the biopolymers chitosan and alginate. Our primary objectives were to enhance stability of dsRNA against nuclease digestion and to mask the negative charge of the dsRNA, which may promote foliar uptake, i.e., overcome plant barriers, such as the cuticle, cell wall and cell membrane. Our approach relies on utilising low polymer concentrations to generate submicron particles, with their charge being either positive or negative determined by the charge ratio during the formulation process. This method incorporates the dsRNA throughout the particle while integrating the nature-derived metal ion chelator, alginate. This serves to inhibit nucleases, which are dependent of metal co-factors. Following this approach, we obtained a high formulation efficiency of > 94 %. Next, we investigated the influence of the charge ratio of positively to negatively charged groups and total polymer content during the formulation process on the size, size distribution and ζ-potential of the IPECs. We discovered that formulating dsRNA with alginate and chitosan at low concentrations ≤ 0.05 g/L produced < 100 nm particles. Moreover, we obtained submicron IPECs at charge ratios ≤ 0.9 (+/-) and ≥ 1.25 (+/-), exhibiting negative and positive ζ-potentials, respectively. Furthermore, the IPEC formulation protected the dsRNA from enzymatic degradation by nucleases. In addition, we observed outstanding protection of formulated dsRNA from heat degradation. Experiments on *Nicotiana benthamiana* plants showed that heat-treated dsRNA formulations offered protection against Tobacco mosaic virus compared to unformulated dsRNA. Further experiments with shorter (448 bp) dsRNA targeting the rice blast fungus *Magnaporthe oryzae* demonstrated that our dsRNA-formulations significantly reduced the necrotic area and fungal mass in *Brachypodium distachyon*. In essence, this formulation demonstrates versatility and adaptability for the production of IPECs with customizable size, surface charge, and nucleic acid content. The incorporation of target-specific dsRNA sequences into this formulation pipeline holds promise for streamlining the large-scale implementation of non-transformative RNAi-based crop protection, such as spray-induced gene silencing.

Innovating Agriculture at Microscopic Level: Using Nanotechnology to Boost Photosynthesis

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Photosynthesis is the biological process that gives us oxygen to breath and food to eat. It has evolved over billions of years, but not for the purpose of feeding an ever growing human population, but rather to pass on the plant's genetic material to the next generation. As such from our point of view it is very inefficient - usually only 1% efficient!

Glaia has a unique technology that makes use of recently discovered carbon-based nanomaterials to directly interact on a cellular level with the photosynthetic machinery of plants to increase its efficiency and thus produce more food. It is a versatile approach, that avoids GM and is virtually applicable to any plant. And because photosynthesis relies entirely on natural resources, we can also decrease carbon emissions from crop production at the same time.

Water and the Agrifood Chain

Chedly Tizaoui

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Water constitutes more than 60% of the mass of most living species and is the most critical of all nutrients used by an organism to survive, grow and reproduce. Agriculture, as the primary consumer of water, accounts for 72% of all surface and groundwater withdrawals **[1]**. Driven by a rising global population, rapid urbanization, changing diets and economic growth, demand for water is increasing rapidly. Not only water quantity poses a pressure on the water-food chain but also pollution is a rising global crisis that directly affects health, economic development, and food security. The degrading water quality is impacting agriculture and poses a significant threat to food safety and food security while agricultural and farming activities have become the dominant source of water pollution. In its recent report on the state of the world's land and water resources for food and agriculture, the FAO estimates that 1260 km^3/year of effluent discharged into the environment, representing 56% of all discharges, come from agricultural drainage. Although pollution from agricultural nutrients (nitrogen and phosphorus) discharge into the environment is a well-established field, concerns are growing about pollution caused by emerging chemical contaminants, including pesticides, pharmaceuticals, microplastics, and antimicrobial resistance, for which regulation and monitoring are scarce. Thus, to withstand current and future demands of water at sufficient quantity and quality, integrated and sustainable management of water and food must be ensured and so the needs of people, the environment and the economy are balanced. This talk will review the water-food nexus and highlight the interactions between the two components. The talk will also highlight the research we conduct to eradicate emerging contaminants from water **[2-7]** and the use of alternative technologies to support food security and sustainable agriculture **[8, 9]**.

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The Holistic Approach to Plant Pest Management

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Integrated Pest Management (IPM) is not a new concept, with the European Union (EU) obliging all professional plant growers to adopt IPM principles since 2014. However, one of the major challenges to IPM may sit within the name itself - Are the pest management strategies truly integrated?

The depiction of the key tools for pest management in the ubiquitous IPM triangle shows plant protection products occupying the smallest top section, yet they remain the first port of call when designing a pest management programme. The idea of an integrated system is to optimise the combined effects of plant protection actions, including indirect actions like nutrition and irrigation. Much IPM research and practice still only focusses on direct plant protection methods. There remains, therefore, scope for a more holistic approach that utilises indirect plant protection methods alongside direct ones.

Traditional agronomic approaches have largely overlooked the importance of the interactions between the plant and its associated environment for development of pest populations; understanding the presence of pests as largely separate from the condition of the crop. However, by taking an approach to agronomy that focuses on enhancing and exploiting natural defensive processes, the activity of the plant can be positively manipulated to protect from pests and limit their establishment. This reduction in susceptibility provides protection from the pest, improves efficacy of biological products and ultimately lowers the requirement for curative pesticide applications, reducing grower input cost and avoiding detrimental impacts on the environment and human health.

This talk will explain how a combination of indirect and direct crop protection methods, based around cultural controls, nutrition and biological products, can be successfully used to grow crops in a manner that is both financially and environmentally sustainable.

Sensors for Environmental Monitoring: Applications, Technologies, Success Stories, Challenges, and Limitations

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The talk delves into the multifaceted role of sensors in environmental monitoring, exploring their diverse applications and the underlying technologies that drive them. It will highlight various real-world success stories, showcasing how sensors have effectively addressed critical environmental issues across different contexts. Additionally, the presentation will address the challenges and limitations faced in the deployment and operation of these sensors, including technical, logistical, and financial hurdles.

Microbial Biopesticides – A Regulatory Checklist for Developing New Products

Ian H. Baxter

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In 2021, IBMA UK was a consultee for DEFRA's 'Sustainable Use of Pesticides: Draft National Action Plan (NAP). IBMA UK polled its members to coordinate feedback as a collective industry group. We wanted to show DEFRA, using clear examples, how the current system is not performing as well as it could be. As well as giving feedback, we also noted that some frustrations with the regulatory process were because products were triggering regulatory cut-offs or that the client was simply not aware of the guidance for new products. To address this, IBMA UK presents here a very basic checklist of characteristics that new products will require for them to be registered and, ultimately, sold in the U.K.

Characterisation and Manipulation of Urban Light Environments for Fly Control

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Filth flies are a strong mechanical vector for over 100 pathogens and therefore of key importance to human and animal health. Urban environments are a preferred habitat due to abundant feeding and oviposition opportunities and warm temperatures. I will explore the current understanding of the visual ecology of filth flies and discuss what remains to be discovered about their visually guided behaviour in urban environments in terms of illumination, object detection and recognition, and interaction with polarised light. I will then demonstrate my current work that uses visible, ultraviolet and polarisation panoramic photography, image processing and visual modelling of filth fly vision to investigate how flies perceive urban environments. Analysis of resulting images representing a 'fly's eye view' can be used to understand the information content and structure of urban environments to flies. Analyses incorporate differences in the visual performance of filth flies including the common house fly, *Musca domestica* and urban Blowflies, Calliphoridae. Findings will allow for better understanding of flies' visually-guided behaviour in urban environments and potential for manipulation of environmental cues to influence behaviour and limit the spread of pathogens.

Biopesticide Regulation in the UK

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To bring a new pesticide active substance to market in the UK it needs to be approved. This is done by submitting an application to the Chemicals Regulation Division (CRD) of the Health and Safety Executive (HSE). Following EU Exit, there have been changes to the regulations which apply and how they are implemented. Active substances marketed in Great Britain must have undergone assessment by HSE. For Northern Ireland however, these must have been assessed under the EU process.

The process through to active substance approval has several stages and specialist support can be sought from HSE before and during the process.

HSE as the UK regulator has additional support in place for biopesticide substances. This includes the Biopesticide scheme which allows reduced fees for biopesticide applications. This is only available for specific substance types but can provide huge savings.

This talk will cover the process for active substance approval and how HSE support biopesticides through this process. It covers information on the above, and background of who the regulator is, a step-by-step of how the process works and how additional biopesticide support fits into this.

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