IMPACT

REDUCING THE NEED FOR ARTIFICIAL FERTILISERS

BIOFECTOR CMAST Fast Track to Value ABiTEP GmbH UNIVERSITY OF HOHENHEIM

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Impact Objective

- Reduce input of mineral fertilisers in European agriculture by development of specifically adapted bio-effectors (BEs) to improve efficiency of alternative fertilisation strategies

Reducing the need for artificial fertilisers

*Through the **BIOFECTOR** project, a diverse European network of 21 research institutions and SME producers of crop bio-stimulants investigate perspectives to reduce the reliance on energy intensive and environmentally problematic mineral fertilisers*

Conventional agriculture relies on regular and liberal applications of artificial mineral fertilisers containing essential plant nutrients, especially nitrogen and phosphorus. Nitrogen fertilisers are made from atmospheric nitrogen, which is converted to ammonium using the energy-intensive Haber-Bosch process, while phosphorus fertiliser is made by treating mined phosphate rock with sulphuric acid. Apart from the high energy cost of producing these fertilisers with limited natural resources, harm is also caused to the environment by their application. Only about half of nitrogen fertilisers and 20 per cent of phosphate fertilisers are taken up by crops. Most of the remainder is immobilised, runs off into waterways, is leached into groundwater or lost in gaseous form. The liquid leachate causes pollution of groundwater sources and leads to the eutrophication of rivers, lakes and coastal zones, thereby reducing biodiversity and producing toxic algal blooms. Because of these damaging effects, many regions - including Europe - are introducing legislation to reduce the use of mineral fertilisers.

In response to the need to maintain crop yields whilst reducing artificial inputs, a number of projects are being funded by the European Commission to investigate more natural ways of sustaining agricultural production. BIOFECTOR (Resource preservation by application of bio-effectors in European crop production) is a major project investigating the use of bio-effectors (BEs) to improve the ability of crops to utilise nutrients from both artificial and natural fertilisers. Coordinated by the University of Hohenheim in Germany and benefiting from the dedicated project management skills of consultancy company CMAST, the project comprises a consortium of 21 industrial and academic partners. BIOFECTOR is now approaching the end of its five-year duration, in which it has tested the effects of 36 BEs in over 150 laboratory and field experiments.

FILLING KNOWLEDGE GAPS

Scientific Coordinator Günter Neumann explains that BEs come in many different forms, including microorganisms, fungi and extracts from algae, plants and compost: 'Some promote root growth, which helps the plant to more efficiently take up fertilisers, and others make minerals more available to the plant by aiding solubility or act as stress protectants.' While there are already many producers of BEs, including SMEs and large corporations, the varied interactions between plants and BEs and between different BEs across a range of conditions, are still poorly understood. 'We have been working to fill this gap in knowledge to promote farming methods with lower input of mineral fertilisers, organic farming and different crop management techniques, to increase or at least maintain yields by searching for the most appropriate BE-fertiliser combinations.' In particular, the effectiveness of BEs has been tested with alternative recycling fertilisers based on animal manures, composts, digestates, ashes, slags and other waste recycling products, but also with approaches to reduce fertiliser consumption by placement strategies close to the roots. Special emphasis was placed also on interfering stress factors, such as temperature extremes, drought or low quality of irrigation water (salinity).

BIOFECTOR brought together SME producers of different types of BEs and academicians from research institutes, to begin the process of determining the most effective means of using BEs to resolve some of these problems', says Neumann. Out of a pool of 72 different BEs, 36 commercial products and novel developments were selected and taken forward for screening and further testing. Laboratory and field trials were undertaken in different climates and situations, representative for European agriculture, including controlled greenhouse conditions and open fields. Maize, wheat and tomatoes were the main representative crops studied.

While the team is still evaluating the results of all the trials, using meta-analysis techniques, the project has already yielded several important findings. 'New products, improved production technologies and BE-fertiliser combinations have begun to define the conditions and application windows in which BEs can be particularly effective,' Neumann notes. BIOFECTOR has thus laid the foundations for continued collaboration between industry and science in this important area to pave the way for farmers to reduce their reliance on artificial fertilisers.

Sustainable bio-stimulants for agriculture

*The **BIOFECTOR** project is quantifying the effect of natural bio-stimulants on agricultural crop production. **Günter Neumann**, **Kathrin Prebeck**, **Helmut Junge** and **Beate Zimmermann** describe the challenges and successes arising from this collaborative European initiative*

Clockwise from top left: Günter Neumann, Kathrin Prebeck and Helmut Junge

Who will benefit from the outcomes of the BIOFECTOR project?

GN: Farmers and bio-effectors (BEs) producers will gain important information regarding suitable conditions for integration of BE products into crop production systems. SME participant producers are also benefiting from the patent applications arising from the project and from the opportunity to test emerging products under different growing conditions. The plant science sector has also benefited from the training of many students and other academics.

Can you talk about what the role of Project Manager has involved?

KP: Since the project started, I have been responsible for organising reporting and meetings, plus contract and communication management. I have also contributed to the work package on dissemination and training. Building the BIOFECTOR network and fostering communication between the project participants, was an element I particularly enjoyed. It was also very positive to see scientific targets being reached in the project.

Managing a consortium of 21 partners can be challenging. Can you talk about some of the hurdles and how you have overcome these?

KP: The basic principle in this strong network has been communication in all forms. Discussing the problems, evaluating options and finding the optimum solution has been our guiding principle. It is also important to have a strong leadership team including the coordinator, a project manager and team leaders for each of the work packages.

GN: When faced with the multiple challenges related to the management of a multi-stakeholder project, I recommend integrating a project management partner. Project management is a key task which has a strong influence on the success of a project; doing this gave me the freedom to concentrate on the science.

How important has input from industry been to the success of the project?

HJ: The development of bio-stimulants is a long and expensive process and needs both scientific input and long duration field trials. The frame of the project offered an excellent chance to learn more about the mode of action of bio-effectors and BE combinations and to study the results of field trials on different plants in a range of environments for five years. BIOFECTOR also gave us the opportunity to build scientific knowledge regarding the complex biological interactions between plant microorganisms and the environment. A main input of the industry partners was the knowledge they held regarding application and use of their bio-stimulant products. Also close cooperation between scientists and the business community is of great importance so that the results of this joint work can be brought to market.

When undertaking field trials in different soils and different climatic conditions how did you ascertain what effects were due to the addition of BEs?

GN: Field testing of promising BE products was performed by our International Field Testing Network on research stations and on-farm trials conducted in eight European countries, representing the different geo-climatic conditions in northern, central and southern Europe. The experimental design followed a defined protocol aimed at acquiring comparable data sets. This included negative controls without BE application and positive controls representing a full mineral fertilisation and fertilisation management according to local farming practice.

How was plant growth promotion measured? Was eventual crop yield the most important factor?

GN: Assessment of plant growth promotion followed different evaluation schemes depending on the experimental conditions and the investigated crop. Biomass production and the nutritional status served as common indicators in all experiments. Also root growth characteristics were evaluated by image analysis. In field experiments final yield and different yield components (including grain weight, kernel

and fruit number, individual fruit biomass and quality factors) were central parameters.

What do you consider to be the most important findings and are you confident the project can help reduce the use of mineral fertilisers?

HJ: The most important result has been finding effective combinations of bio-stimulants with special nitrogen fertilisers and selected micronutrients. Furthermore, a new Bacillus strain was identified, which displays good effects under cooler climatic conditions. Some combinations of different BEs performed better than single variants and these are being patented.

GN: Apart from the development of novel products and improved production technologies (three patent applications, development of three promising combination products) BIOFECTOR provided valuable new insights into the right set of circumstances and the optimum application windows for use of BEs. In the right conditions, BEs can assist plant nutrient acquisition and help the host plant to cope with reduced nutrient availability. As a final output, a meta-analysis is being compiled by all consortium partners to include all model and field experiments conducted within the project. It is expected that this will facilitate the interpretation of the numerous field results. Although, at the moment I do not see that BEs can offer a general perspective for large reductions in the use of mineral fertilisers in agriculture, BIOFECTOR could characterise conditions where their use can be highly efficient. Interestingly, various different BEs performed equally well whenever it was possible to establish such a right set of circumstances. This demonstrates that it is possible to define environmental conditions generally supportive for the establishment of plant-BE interactions. The challenge is to identify these conditions and their perspectives for integration into agricultural practice. Investigations on interactions with native soil microbial populations demonstrated that the effects of using various representative microbial BEs were significant but generally transient, suggesting that long-term effects are not very likely.

Do you think that sludge, digestates, composts and manure, in combination with BEs, can offer an alternative to mineral fertilisers?

GN: Among the various tested organic fertilisers, the best BE effects were observed in combination with composted farmyard manure, although not all manure-based fertilisers performed equally well. It was surprising to us that the BE products we tested did not perform as well as hoped in combination with sludge and digestates, slugs or ashes. However, we noted that the efficiency of BEs can be improved by triggering some of the plant's own mechanisms for nutrient acquisition by simultaneous application with ammonium fertilisers. Similarly, micronutrient fertilisers with functions in stress defence improved the performance of various microbial and non-microbial BEs towards improved stress tolerance of the investigated crops. This underlines the importance to consider also host plant adaptations for the development of BE applications.

What have been the results of cost benefit evaluations?

BZ: BIOFECTOR has shown that specific bio-effectors can help induce remarkable economic benefits under the right conditions. However, for the optimised applications developed within the project run time, frequently based on not yet commercialised BE products or product combinations, a detailed cost benefit calculation based on various field experiments is still in process.

Have there been any public open days or other dissemination events?

GN: We have begun to disseminate our findings to the agricultural sector through scientific literature and agricultural journals. Additionally, field trials and results were presented on public field days organised by the experimental stations of the consortium members and farmers associations. In addition, four successful international summer schools have been organised at the Universities of Prague, Timisoara, Budapest and Naples.

From your perspective, what are the next steps, open questions and problems to address beyond the current activities of BIOFECTOR?

HJ: The development of biological compounds for sustainable agriculture is a very complex mission and needs a long-lasting and intensive collaboration between science and commerce. However, we also need to address the regulatory environment. The EU is setting up new regulations for the approval of bio-stimulants, which will represent a high hurdle to market launch. Hopefully BIOFECTOR will provide a better understanding of the possibilities and opportunities of BEs and their environmentally friendly mode of actions.

Project Insights

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