BIOFECTOR Report Summary

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Periodic Report Summary 1 - BIOFECTOR (Resource Preservation by Application of BIOefFECTORs in European Crop Production)

Project Context and Objectives:

Covering the demand of a growing world population for production of food and energy crops in face of the limited area of productive agricultural land is one of the big challenges during the next decades and requires resource-saving agricultural production strategies and land use intensification. As a prerequisite, more viable plant nutrition strategies as alternatives for the prevailing use of mineral fertilisers, mainly produced by direct or indirect exploitation of non-renewable natural resources, are urgently needed. However, use efficiency of alternative fertilisers is frequently biased by limited rooting and nutrient immobilisation.

BIOFECTOR is an integrated project with the aim to develop strategies for reduced input of mineral fertilisers in European agriculture, using specifically adapted bio-effectors (BEs) to improve the efficiency of alternative fertilisation strategies, such as organic and low-input farming, use of fertilisers based on waste recycling products and fertiliser placement technologies. The so-called BEs addressed within the project comprise various fungal and bacterial isolates, natural extraction products of seaweed, compost and plant extracts with root growth-promoting and nutrient-solubilising potential but without significant contents of plant nutrients. The basic idea is the selection and further improvement of BEs exerting their beneficial effects on plant growth specifically under the characteristic conditions of the respective alternative fertilisation systems, thereby increasing plant efficiency for nutrient acquisition or the nutrient availability of the fertilisers. Maize, wheat and tomato are chosen as test crops representative for European agriculture.

Within the consortium, BEs with putative plant growth-promoting potential are provided by five European companies with expertise in selection, screening and formulation of BE products. Apart from single BEs, also synergistic effects of product combinations are investigated. For products with a proven record of plant-growth promotion, the underlying mechanisms are characterised at the molecular and physiological level also including their impact on native soil-microbial populations to consider putative effects on soil ecology and bio-safety. The potential of the selected BEs for improvement of alternative fertilisation strategies is evaluated in standardised model experiments under controlled environmental conditions, followed by small-scale field trials. Successful products are finally assessed within the “BIOFECTOR International Field Testing Network”, providing standardised field experiments in 9 countries under the geo-climatic conditions representative for European agriculture. The field-testing network also provides the base for public demonstration trials and the data for a cost benefit analysis of the newly developed fertilisation strategies in comparison with conventional practice. Further scenario and/or simulation analyses of representative approaches will be conducted to depict the economic efficiency under varying (world) market and price conditions to approve their economic viability and sustainability.

Perspectives for patenting, registration, and international marketing of novel BE products in different countries are investigated and developed in close cooperation of all contributing project partners. Training activities comprise organisation of training courses on application technology for BE products for extension service and farmers, as well as student workshops on BE research. A public data base, collecting the current knowledge on perspectives for application of BE products in agricultural practice is installed as an information guide for farmers and scientists and as a platform for producers of bio-effectors to present products with a proven record of efficiency.

Project Results:

During the first year, a representative pool of 72 BEs was provided by BE-producing companies of the consortium for further characterisation. Apart from commercial products, this pool includes also novel BEs specifically selected for applications within the alternative fertilisation strategies addressed by the project, such as P-solubilising bacteria or bacterial strains with low-temperature and salt tolerance. Out of this pool, 27 BEs have been selected for the first screening programmes. Special emphasis was placed on three commercial microbial BEs with proven records for plant growth promotion and available molecular tracing tools for root-colonisation. These BEs were selected as standards, representative for the most widespread microbial BEs, based on Bacillus, Pseudomonas and Trichoderma.

To achieve comparable results, a strong focus was placed on methodological standardisation of the screening experiments. Guidelines for pot experiments, considering experimental setup, application of BEs, harvest and methods employed for sampling and plant analysis, including a handbook with methods available within the project were established and distributed within the consortium. Soil analysis was organised by a central lab.

Similar guidelines were established for field experiments within the BIOFECTOR-International Field Testing Network. Special emphasis was placed on a standardised experimental design, enabling final cost-benefit evaluation of the novel fertilisation strategies in comparison with conventional practice and scenario analyses to simulate their efficiency under varying market conditions. A spread sheet-based field trial documentation tool and a user manual were developed for all included crops. First test runs were performed based on literature data. Moreover, the field trial guidelines were designed to meet the standards of the “European and Mediterranean Plant Protection Organization” (EPPO), required for the registration of new products. A first set of field experiments was conducted in Romania with tomato, maize and spring wheat inoculated with Bacillus-, Pseudomonas-, and Penicillium-based BEs, allowing first evaluations under practical conditions.

As expected, the results of the first BE screening programmes revealed high variability. In tomato and maize, particularly the Pseudomonas- and Bacillus-based BEs exerted plant-growth promoting effects in greenhouse experiments on substrates with low and moderate P availability (Fig.1). The underlying mechanisms are currently investigated in joint experiments. However, in presence of additional stress factors, such as temperature extremes, the beneficial effects completely disappeared even in test programmes with large numbers of different BEs.

Interestingly, BE-induced plant growth promotion was not only observed under limited nutrient supply: in tomato and also in maize, Bacillus-, Pseudomonas-, Trichoderma-, and Penicillium-based BEs were particularly effective in substrates amended with high levels of composted manures (Fig.2). The similar effectiveness of different microbial BEs under these conditions points to a general principle, which requires further investigation and is particularly promising for organic farming and fertilisation systems based on recycling fertilisers.

Other promising BE effects have been reported for plant growth promotion by Sebacinales and extracts of Sorghum and Trichoderma in tomato, increased salt tolerance of tomato and lettuce treated with salt-tolerant Azotobacter strains and seaweed extracts, and increased cold tolerance in maize by micronutrient seed treatments. Currently no BE responses have been recorded for wheat, suggesting interspecific differences in the responsiveness of test plants.

Web-based structures have been established as internal communication and public dissemination tools, including the BIOFECTOR web page and an open data base on BE evaluation, which is now ready for data entry collected from European BE producers.

Potential Impact:

Profit for environment

Mining and production of mineral fertilizers and transport across continents is vastly energy-inefficient, expensive and produces greenhouse gases. A synergistic combination of bio-effectors (BEs) with alternative fertilisation strategies, such as organic farming, fertilisers from recycling products, single plant-adapted fertilisation (precision farming, fertiliser placement, fertigation) revives the classical concept of local and regional nutrient cycling and offers the perspective to reduce mineral fertilizer input. Including industrial and urban waste as renewable nutrient sources and their successful application will facilitate regional waste management. The implementation of BEs in European farming

practices can contribute to greenhouse gas reductions not only by soil carbon sequestration and agricultural biomass production with less input of mineral fertilizers but also by saving production and transportation costs.
Profit for European citizens, food security, human welfare
Benefits of the novel alternatives to mineral fertilisation comprise food security in terms of price stability in face of decreasing resources and of rising mineral fertilizer costs for farmers. Energy savings and climate conserving aspects also improve social welfare and well-being.
Profit for farmers
Reduced dependencies of farmers to fluctuating fertilizer prices is an immediate profit but soil conservation, preservation of soil fertility, reduced run-off and erosion are probably the most important benefits. The European demand for organic farming products is steadily increasing and plant products originating from alternative nutrition strategies will support these markets. The open information data base on BEs in agriculture will provide a tool for farmers for better assessment of the potential efficiency of BE products and for selection of BEs according to their specific requirements.
Profit for SMEs, economy and industry
Realistic field-testing of the novel BE-fertilisation strategies under different European geo-climatic conditions in the BIOFECTOR-International Field Testing Network is a unique infrastructure and an extraordinary opportunity for each SME, commonly lacking sufficient resources for intensive field-testing. Furthermore, increased public awareness of BE products may support registration and marketing in different European countries. SMEs will identify test market countries and follower countries and get European-wide experiences with BE products that allow country-specific formulations, package size, pricing, and distribution. As the European fertilizer market is worth millions of Euros, it is likely that the larger demand for BEs will later entail larger industries to cope with the increasing BE demand. Because mining and transportation costs for mineral fertilizers will further increase, local waste recycling product suppliers will flourish and regional economies will get more independent of foreign input.
Profit for research and scientific knowledge transfer
BEs often provided plant growth improvements in laboratory experiments but only diffuse knowledge verifies their field efficiency. Quantitative evaluation of the yield potential of the most promising BEs under standardized conditions within the BIOFECTOR-International Field Testing Network will allow the generation of a reliable basis for a realistic benefit analysis of BE products at the European level and also on a global scale. International researchers, SMEs and farmers are brought together and will profit from the multidisciplinary and integrated research approach. Internationally recognized research experts in soil science, microbiology and plant science share their knowledge to improve the understanding of BE effects, from molecular to landscape scales. Young scientists are educated and distribute local knowledge. These synergisms will promote research and a successive development of novel competitive BE products.

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