

**Anna Grobelak, Anna Napora, Joanna Hiller, Małgorzata Kacprzak**  
**Politechnika Częstochowska, Faculty of Infrastructure and Environment,**  
 Brzeźnicka 60a, 42 200 Częstochowa, agrobelak@is.pcz.czyst.pl

## **ANALYSIS OF COMMERCIALISATION POSSIBILITIES OF BIOPREPARATION „ RHIZOFERTUM” FOR PLANT GROWTH STIMULATION IN UNFAVOURABLE SOIL CONDITIONS**

### **Abstract**

The aim of the paper was to discuss commercialisation possibilities of research findings pertaining to the biopreparation for plant growth stimulation in unfavourable soil conditions, which is based on specialized bacterial consortium. The production foundation of the biopreparation is the technology regarding the immobilisation of micro-organisms on mineral-organic media and sodium alginate, taking the form of a capsule. As a result of the conducted analyses, the potential effectiveness of investment in the technology and available solutions on the market were assessed in addition to strengths and weaknesses of the biopreparation. It was also stated that the prospective benefits following from the commercialization of the invention are very high.

**Key words:** commercialization, biopreparation for plants growth stimulation, fertilisers market

### **Technology description**

The production of the biopreparation for plant growth stimulation is based on the technology regarding the immobilisation of micro-organisms on media. The micro-organisms used in the production of the biopreparation are taken from, inter alia, the strain collection of the Institute of Environmental Engineering: *Pseudomonas fluorescens*, *Bacillus* sp., *Azospirillum brasilense*, *Bacillus subtilis*, *Bacillus* sp., *Bacillus mycoides*, *Bacillus anthracis*, *Pseudomonas putida*, *Pseudomonas* sp. Bacteria were isolated from heavy metals contaminated soil. Endophytic and Rhizobiaceae bacterial strains were isolated from the plants: *Festuca rubra* L., *Agrostis capillaris* L. and *Arabidopsis thaliana* L. Heynh. Isolates were sequenced by 16S rRNA sequence analysis. The micro-organisms are immobilised on the mineral-organic media and sodium alginate, taking the form of a capsule (Fig. 1-2). The used bacteria strains demonstrate the ability to produce indole-3-acetic acid and to decompose 1-aminocyclopropane-1-carboxylic acid, assimilate atmospheric nitrogen, decompose phosphates, and they possess proteolytic and antifungal properties.



Fig. 1. The production of the biopreparation for plant growth stimulation is based on the technology regarding the immobilisation of micro-organisms on media

Source: Author's

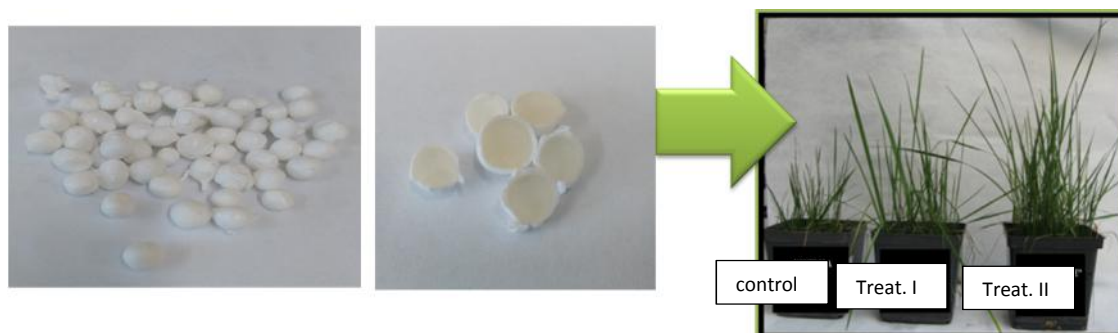


Fig. 2 The micro-organisms are immobilised on mineral-organic media and sodium alginate, taking the form of a capsule (bacteria treatments I,II and control without bacteria with blank capsules)

Source: Author's

The existing achievements within the scope of testing the developed technology covered the following actions [1, 2]:

- bacteria-plant interactions were correlated and better understood – they are essential in order to fully develop the biotechnological prospects of bacteria-plant partnership, and their broad usage,
- higher plant yielding was achieved, including grass as well as rapeseed, in very unfavourable soil conditions (low nutrients content and high heavy metals concentration), with low content of mineral components and considerable soil contamination,
- antifungal metabolites of bacteria were detected in specified strains, especially with respect to fungi *Fusarium* sp. and *Alternaria* sp., which allows us to produce much better yields and to lower the amount of fungicides used in plant cultivation (including rapeseed),
- growth increase of plant biomass (rape, fescue grass) was achieved (30- 60% depending of plants and soil conditions) while cultivating poor soil, which creates the possibility to lower or entirely eliminate the necessity to use mineral fertilisers, including nitrogen and phosphorus,
- the most favourable results were obtained when micro-encapsulation technology with the usage of nano-silica was introduced.

#### Preparation stages for commercialization

Within the framework of the development, the following stages were carried out:

- market analysis where the technology is applicable,
- analysis of attractiveness of the technology/product based thereon with respect to the existing substitutes,
- competitiveness assessment, including strengths and weaknesses of the product, chances and threats,
- the list of main success factors and potential risks,
- defining the effective path of technology commercialization.

As a result of the conducted analyses, the potential effectiveness of the investment in the technology and available solutions on the market, and also strengths and weaknesses of the biopreparation for plant growth stimulation in unfavourable soil conditions (low nutrient content and high heavy metals content), it has been stated that prospective benefits following from the commercialization of the invention are very high.

While choosing the optimal path of technology transfer, it is to be assumed that the most crucial element of the effectiveness evaluation is above all the capital effect, i.e. raising capital for research and organization development, returns on investment and income. The most essential problems in the transfer of technology pertain to the issues: whether the technology should be sold directly, whether and how licenses should be granted and whether and how intellectual property should be contributed to the enterprise. Granting a license or contributing intellectual property to a company depends, above all, on the readiness to take risks, occurring while running a company and selling technology, on resources and personal competences of employees of the enterprise (the purchaser of the license or intellectual property) and on the influence of the shareholder, contributing intellectual property, on the decisions of the company and on the amount of the expected dividend contingent upon the amount of company shares [3]. The main conditions that underlie the granting of licenses as an alternative with respect to the commercialization through establishing a new company are:

- licensing income,
- venture profitability,

- the level of risk associated with running a business activity,
- competence in technology development,
- influence on decision making (shares in the company, representation in the management board and the board of directors).

The selection of the commercialization path is also dictated by the current aims of the university and the possibilities of further engagement in the process of creation of an innovative product. As it is confirmed by Trzmielak [3], while analysing the cooperation between the entrepreneur and scientists in order to implement research findings, it is necessary to mainly pay attention to different aspects of the functioning of these entities.

Due to the aspiration of the European Union to introduce organic farming and the promotion of organic food [4], the developed preparation fits in the policy of the European Union. One advantage of this biopreparation is that it virtually covers the entire biopreparation market in the context of their properties (Fig. 3-4) – it may fix nitrogen and transform phosphorus into forms assimilable for plants [2].

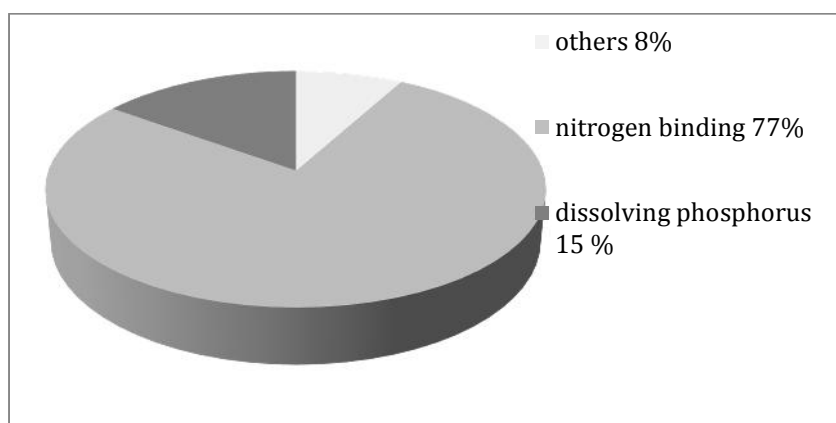


Fig. 3 Biopreparation global market

Source: Author's

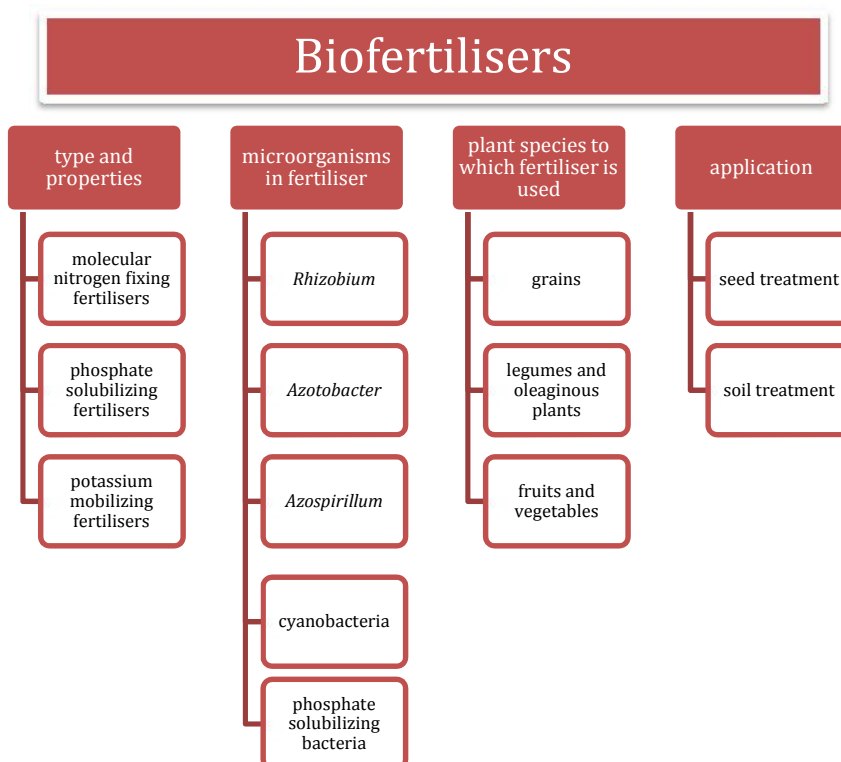


Fig. 4. Biopreparation market – the division into properties, micro-organisms, plants and application

Source: Author's

The offered product complies with the latest market needs, inter alia, due to its “environmental performance” and increased efficiency. Additionally, it limits its potential costs resulting from the necessity to repeat application procedures. It is estimated that from 2014 to 2019 there will be a biofertiliser market growth of up to over USD 1.6bn, with an average annual growth at around 13% [5]. The growth of this market is connected with the growth of the organic food industry, the increased rate of consumption thereof and an increase in awareness of the society with respect to health and threats resulting from the application of chemicals in agriculture. Fertilisers fixing molecular nitrogen, biofertilisers used in seed treatment and biofertilisers for grains, fruits and vegetables are dominant on the biofertiliser market. In the EU states there is no legal definition of biofertilisers or specific legal provisions defining their properties. There are, however, legal regulations within the scope of organic farming. The analysed biopreparation may be also applied on the market of soil improvers, whose production in the EU is estimated at around EUR 1.13bn and 3.37 tonnes. The next market is the market of biostimulants driven by the policy emphasizing the popularization of organic products. The largest development of organic farming, which is strictly connected with the application of biofertilisers and biostimulants, is observed in Spain, Italy, Germany, Great Britain and Poland. It should be indicated that in many reports there is information on high biofertiliser market saturation in the European Union which may constitute a problem in entering the market with new products. The key matter may also be price competitiveness [5].

### SWOT analysis of the technology

The SWOT analysis of the technology was carried out. The strengths include: having a good product concept, potentially high profitability of activity, proecological solutions – beneficial impact of the solution on soil quality that is directly used by the final consumer of the product. Additionally, the product is based on bacteria appearing in the natural environment in Europe, which results in higher efficiency and sustainability of the solution in our climatic conditions. Moreover, the form of the solution has positive influence on the application over smaller areas, slow releasing, longer activity, potential favourable impact of solutions on the profitability of recipients, innovative technologies, combining experiences from different industries [5, 6].

The SWOT analysis (Tab. 1) also reveals the weaknesses: start-up project: the lack of knowledge on the industries, the lack of established business relations, limited financial resources, future dependencies on key recipients, employees and suppliers, the necessity to conduct further research on the developed solutions requires substantial funding, the necessity to broaden the possibilities of application through the development of alternative product forms (hard shell, or liquid form).

Table 1. The SWOT analysis of the studied solution

Strengths	Weaknesses
<ul style="list-style-type: none"> <li>▪ Having a good product concept,</li> <li>▪ Potentially high profitability of the activity,</li> <li>▪ Proecological solutions – the positive impact of the solution on soil quality which is directly used by the final consumer of the product,</li> <li>▪ The product is based on bacteria appearing in the natural environment in Europe,</li> <li>▪ Higher efficiency of the solution,</li> <li>▪ Sustainability of the solution,</li> <li>▪ The granular form of the solution has positive influence on the application over smaller areas,</li> <li>▪ Slow releasing, longer activity,</li> <li>▪ Potential favourable impact of the solutions on recipient profitability,</li> <li>▪ Innovative technologies.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Start-up project: the lack of knowledge on industries, the lack of established business relations,</li> <li>▪ Limited financial resources,</li> <li>▪ Future dependency on key recipients,</li> <li>▪ Future dependency on key employees,</li> <li>▪ Future dependency on suppliers,</li> <li>▪ The necessity to conduct further research on the developed solutions requires substantial funding,</li> <li>▪ The necessity to broaden the possibilities of application through the development of alternative product forms (hard shell, or liquid form),</li> <li>▪ Difficult production of biopreparation,</li> <li>▪ Poor microbiological knowledge of potential users,</li> <li>▪ High cost of product</li> <li>▪ Lower efficiency than chemical agents.</li> </ul>

Opportunities	Threats
<ul style="list-style-type: none"> <li>▪ Prospective, niche market,</li> <li>▪ Limited competition on the market of products for bioremediation in Poland,</li> <li>▪ Favouring proecological solutions by legislature,</li> <li>▪ “Bio” product lobby by the media,</li> <li>▪ The possibility to obtain Union funds for the implementation of proecological solutions.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Strong competition with respect to foreign players, especially on the fertiliser and plant protection product market,</li> <li>▪ Stronger competition after the launch of innovative solutions,</li> <li>▪ The lack of knowledge as to the market reaction time of waiting with reference to the developed solutions,</li> <li>▪ The lack of interest in the product offer.</li> </ul>

*Source: Author's*

### Market analysis

For efficiency purposes, understood as a potential profitability of commercialization of research findings, it is recommended that the path based on the establishment of a spin-off company and the commercialization of research findings on the basis of licence sales be applied. The market analysis indicated that in the case of biopreparations for agriculture, the largest amount of patents is in the possession of the Swiss company Syngenta AG, specializing in the production of agrochemicals. If there is a wish to expand the scope of invention protection, there is a high probability to obtain a European patent in EPO. It is, however, not recommended to cooperate on the basis of know-how sales due to the risk of knowledge acquisition on the technological specification. The conducted analysis of companies acting on the fertiliser and plant protection product market results in the observation that there are many enterprises characterized by the proecological approach, offering preparations that have positive influence on the natural environment [5, 7].

Currently, the growth of the global biofertiliser market is observed as it is driven by, above all, the growth of the organic food industry. A different factor is connected with the promotion of organic food and farming by government agencies. According to Grand View Research, the key factors for the development of the market and the growth of demand for biofertilisers till 2020, especially in the USA and the European Union, are legal regulations. A global fertiliser market growth is estimated from 2014 to 2019 up to USD 1.65bn in 2019 (CAGR at the level of 13.9%). Transparency Market Research estimates a growth with a slightly lower CAGR (13%) up to USD 1.03bn in 2019 [5].

The conducted analysis of technology application proves that the potential of generating revenues from product sales with the application of biofertiliser production technology is relatively high. Basically, the main limitation of generating revenues from the developed technology is the accessibility of funding sources of investment outlays. The product may be dedicated to bulk consumers, large agricultural, horticulture and fruit farms [8]. Large entities also possess the potential to alternatively mass produce the developed solution. Bulk customers, large agricultural, horticulture, and fruit farms will be interested in the product, which may be relatively easy in application over a vast area by means of agricultural machinery. This functionality is guaranteed by preparations developed, e.g., in hard shell or liquid form. The aim of further research and development activities will be connected with working on a product form which will be competitive for bulk customers. It should be noted that currently available products on the biofertiliser market are present in the formula of easy-to-apply products. The existing product forms is, therefore, an essential factor limiting the application of the product in the area of bulk customers, but it does not limit the sales of the preparation to non-bulk customers, including, above all, small agri-horticultural farms, households. First of all, investors should be sought among:

Firstly, national entities – they may consist of both the domestic enterprises from markets characteristic for the analysed investments, as a rule they have small and medium scale of operation, as well as trading companies, operating within the frames of large industry corporations, dealing with the distribution of products on the Polish market (they always facilitate the process of reaching out to the parent company in contrast to the direct reaching out to holding companies).

Secondly, companies with small and medium scale of operation – i.e. entities generating at least several million from trade and achieving profitability of the operation – as these companies have limited research resources,

and they are characterized by a higher tendency to invest in “foreign” technology, and it is easier to reach them.

With the aim of achieving efficiency understood as a potential profitability of the commercialization of research findings, it is recommended that the path based on the establishment of a spin-off company be introduced. When founding this company, it is necessary to take actions that are to attract investors to the venture, who will ensure funding of the project and limit the risk level. It should be noted that licensing and the sale of invention rights will apply, most of all, after laboratory work has been finished, full product characteristics has been developed and which has been at least in part verified from the practical perspective. In the case of the analysed technology, three crucial research and development works are to be conducted in the next two years. Only after they are commenced and when they are significantly advanced, it will be possible to start searching for investors interested in purchasing the license of the technology or rights thereto. It can, however, be expected that establishing full cooperation with an investor will be possible after this stage is finished or when the investor will seek to link the remuneration on the account of technology licensing with the results of these works to which the university will be obliged. The sale of the rights before the end of this stage is unlikely. The data analysis of the funded companies of the studied sector indicated that the average EBITDA margin is equal to approximately 17%, and the net profitability is 13% (median 11%). These value are only of informative nature as: i). the test of companies in the analysis is relatively small which results from limited access to data and a relatively low number of companies typically dealing with bioproduction in these sectors, ii). the structure of profit generation in the analysed enterprises is not known in detail. The preliminary economic forecast, conducted for the years 2019 – 2021, indicated that prospective introduction of the developed technology in a business activity has large potential. Key areas of competitive advantage have also been defined.

Key factors of the potential success of the developed venture pertaining to the production of the analysed preparations are:

- high qualifications of technology creators which translates into the quality of the developed solution,
- two alternative possibilities of product application lowering the effects of the lack of unfavourable product reception by one of the sectors for an effective investment,
- positive effect of the products on the natural environment:
- rising significance of proecological products in different areas of economy ,
- rising awareness of the society regarding the necessity to protect the environment and the possibility to substitute chemicals with proecological preparations
- linking the offered products with segments seen as attractive from the investment point of view facilitates access to funding sources,
- access to a laboratory centre and team,
- proecological policy of legislature,
- high efficiency of the developed solutions in comparison to substitutes,
- production based on modern but relatively easy equipment base,
- innovative technologies,
- potential connection of experiences from different industries.

### **Summary and conclusions**

The conducted analysis on the application of the technology states that the potential of revenue generation from the sale of products involving the technology of biofertiliser production is very high. The financial analysis proves that only the construction of a company characterized by a large scale of operation leads to the generation of a positive return on equity. The main barrier connected with entering the market of biopreparation production is the development of a concept of producing such preparation, and the commercialization of research findings in the area of biofertilisers is possible. The conducted analysis of sector companies indicated that the production of these preparations is profitable. The offered product is consistent with the recent market demand, inter alia, due to its “environmental performance” and an increased efficiency. It is therefore essential to take action to obtain financing, at the initial stage in the creation of a production installation and to carry out very costly marketing activities and the construction of a sales network. The analysed solution provided grounds to state that the commercialization of research findings in the area of biofertilisers is possible.

### Acknowledgements

The evaluation of potential of technology commercialization was prepared on the basis of a study drawn up by Polska Grupa Wspierania Innowacyjności Sp. z o.o. (<http://www.pgwi.pl/>) within the framework of the project TANGO1/266740/NCBR/2015.

The work was conducted within the framework of the project TANGO1/266740/NCBR/2015 “Opracowanie technologii wytwarzania biopreparatów złożonych o kontrolowanym uwalnianiu do remediacji gleb i wspomaganie wzrostu roślin” (“Technology development regarding the production of complex biopreparations characterized by controlled releasing for soil remediation and plant growth stimulation”)

### References

- [1] A. Grobelak, A. Napora, and M. Kacprzak, The impact of plant growth promoting bacteria (PGPB) on the development of phytopathogenic fungi. *Folia Biologica et Oecologica*, 10.1 (2014): 107-112.
- [2] A. Grobelak, A. Napora, M. Kacprzak, Using plant growth-promoting rhizobacteria (PGPR) to improve plant growth. *Ecological Engineering*, 84, (2015), 22-28.
- [3] D. Trzmielak, Współpraca ośrodków naukowych i przedsiębiorstw we wdrażaniu wyników badań, *Marketing Instytucji Naukowych i Badawczych* nr 3(4), (2012), 19-36.
- [4] G. Niewęglowska, *Gospodarstwa ekologiczne w Polsce*. Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej - Państwowy Instytut Badawczy, Warsaw, 2005
- [5] Polska Grupa Wspierania Innowacyjności (PGWI) Sp. z o.o. Analiza rynku docelowego dla rozwiązania technologicznego. Rozwiązanie technologiczne: „Opracowanie technologii wytwarzania biopreparatów złożonych o kontrolowanym uwalnianiu do remediacji gleb i wspomaganie wzrostu”, Częstochowa, 2016, pp. 1-149.
- [6] L. Sas Paszt , B. Sumorok, A. Lisek, E. Derkowska, P. Trzciński, A. Harbuzov, S. Głuszek, E. Malusà , *EkoTechProdukt Newsletter*, 19, grudzień (2013), 1-6.
- [7] G. Nachtman, M. Żekało, *Efektywność ekonomiczna gospodarstw ekologicznych na tle konwencjonalnych w 2004 r.*, Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej - Państwowy Instytut Badawczy, Warsaw, 2006.
- [8] S. Białoskurski, Ocena oczekiwań nabywców finalnych wobec nowych produktów spożywczych, *Acta Innovations*. 15 (2015) 35- 44.