

Bioencapsulation for Smart Delivery

of Agriculturally Important Microorganisms

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Beneficial microbes are available in different formulations, the common types being liquid, peat, granules, and freeze-dried powders. Nevertheless, a promising advancement would be to develop techniques that allow encapsulating the microbial strain in a nutritive shell or capsule and deliver them to the targeted site. This would ensure precision delivery, lower application, easy handling and cost-effectiveness. Hence, a major area of focus was development of novel delivery systems of bacteria and fungi for growth promotion, soil nutrient solubilisation and biocontrol.

Key words: Bioencapsulation, Microbes, Soil nutrient

FORMULATIONS of microbes like bacteria and fungi can be used to enhance soil nutrition, plant growth and biocontrol.

Socio-economic relevance of this work

- Precision delivery of biocontrol strains with higher microbial counts by encapsulation and therefore greater residence time in the rhizosphere ensures quick resolution of diseases infecting plants, faster mobilization of nutrients and positive plant growth and yield.
- Easy handling, higher shelf life and higher microbial population due to encapsulation have made biofertilizer application more efficient, feasible and sustainable to the farmers.
- The encapsulation technology is not restricted to spice crops alone, but can be used to encapsulate any microbial strain across any crop.

Technological Relevance

- The role played by beneficial microorganisms is very critical in agriculture and they play a vital role in maintaining soil quality, besides enhancing environmental quality. The technical exactness required,

time consuming and cumbersome procedures in their method of use are factors which has made the use of beneficial micro-organisms unattractive. There are also concerns about the quality of the commercial formulations available in the market.

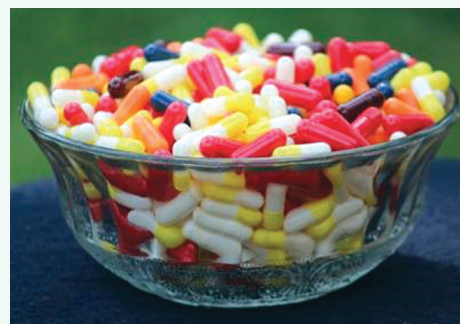
- It was the realization that a more convenient method of delivering beneficial micro-organisms could positively influence the adoption rates, that prompted the search for an alternative delivery mechanism. A major advancement would be to encapsulate beneficial microbes and deliver to crops.
- The encapsulation technology while

considered a breakthrough is also an easily perceptible and understandable technology and unlike the conventional talc, liquid and peat based formulations, the biocapsule technology permits easy handling and use with precision delivery to crops. It marks an acceleration of technological progress in the delivery of microorganisms to crops and at the same time enhancing soil biological quality.

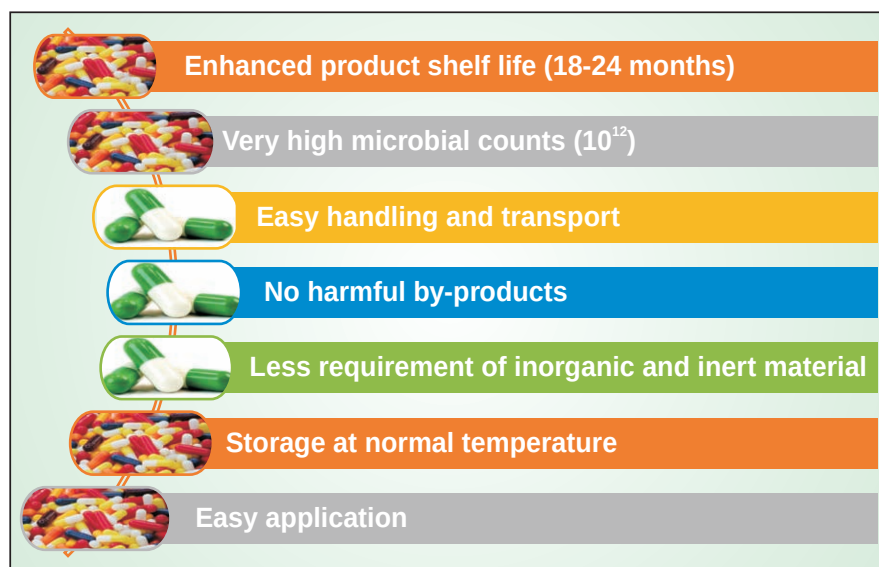
Scientific relevance of the work

- A major spin off from the encapsulation technology and PGPR/fungal formulations is the

Novel method for smart delivery of agriculturally important microorganisms- a first in the world biofertilizer industry. Commercialized by non-exclusive licensing to two biofertilizer companies and the process patent was filed in 2013, with subsequent first examination reports on the patent filed in 2016.



Patent filed: A Novel Method of Storing and Delivering Pgpr/Microbes through Biocapsules
Application No.3594/CHE/2013 dated 13/08/2013.



Novelty of biocapsule technology.

extent of reduction in harmful fungicides/chemical contaminants being added to crops and ultimately the soil. This will ensure clean crop production with fewer chances of the produce being rejected by the consumers/exporters/importing countries.

- The bio-capsules containing beneficial micro-organisms are generally used for promoting plant growth, providing protection against biotic stresses and enhancing availability of nutrients. By supplementing fertilizer application with bio-capsules, it is possible to reduce the use of traditional fertilizers by 20-30%.

Potential value of the research results in increasing production, productivity, profitability and sustainability of agricultural enterprises

- This is the first time in the world's biofertilizer industry that a robust encapsulation technology for smart delivery of agriculturally important microorganisms was developed and non-exclusively licensed to private industries for mass production and distribution.
- The technology provides a much easier and cost effective (cost benefit ratio 1: 3) compared to talc based formulations, which are currently in vogue.
- The encapsulation technology appears to be significant game changer because it can be used to deliver all kinds agriculturally

important microorganisms like nitrogen fixers, nutrient solubilizers, PGPR, Trichoderma, etc.

- The technology has captured the imagination of a wide range of end users and stake holders and is being touted as one of the most innovative agricultural technologies in the country.
- The biocapsule technology has definitely given a fillip to the efforts in promoting green agriculture in the country and is catching up fast in different states. There is absolutely no doubt that the technology will revolutionize the world biofertilizer industry in the years ahead.
- No wonder that the first licensee M/s Codagu Agritech was one of the 17 start-ups in agricultural sector from the country invited for presentation before the Hon'ble President of India Shri Ram Nath Kovind during the Festival of Innovation and Entrepreneurship (FINE), a unique initiative of the Office of the President of India to recognize, respect and reward grassroots innovation, on 19 March 2018 held at The President House of India New Delhi.

Crops covered by the biocapsule technology

Spices: Black pepper, ginger, turmeric, cardamom

Leguminous crops: Pea, Pigeon pea, Black gram, Green gram, Chick pea, Cow pea, Soybean, Peanut,

Lentil, Berseem etc

Vegetables: Lettuce, Cabbage, Cauliflower, Brinjal, Capsicum, Gourds and other cucurbits

Tree crops: Clove, Nut mug, Cinammon, Mango, Apple etc.

Beverages: Tea, Coffee, Cocoa, etc

Fruit crops: Grapes, pineapple, Banana, Strawberry etc.

Spread of biocapsule technology in India

The technology has now spread to majority of the spice cultivating states like Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Madhya Pradesh, Gujarat, Uttar Pradesh, Himachal Pradesh and even NE states like, Nagaland, Sikkim, Tripura etc. (Table 1) covering approximately 15% of the area and we expect it to double by the next 5 years.

Impact of encapsulated delivery of agriculturally important microorganisms

- The benefits from the technology can be visualized at three levels. The gains to the technology developing institute, the gains accruing to private firms involved in the manufacturing and distribution of the technology and the benefits to the end users (farmers) of the technology.
- The gains from the technology across the three levels were estimated to be 21.82 crores for the year 2018-19 in spices crops alone. The benefits in other crops (vegetables, fruits, ornamentals etc) will be multi-fold.
- The cost involved in production of the capsules and the cost of technology adoption have been deducted from the gross value generated by the technology. Conservative estimates are used for evaluating user benefits and the real impact could be of higher magnitude.
- Apart from these monetary gains, use of bio-capsule technology has also promoted organic input use in agriculture reducing the need for chemical inputs.
- By using bio-capsules, the avoided quantity of plant protection chemicals is estimated to be 75.6

Table 1. Details of biocapsules developed by our licensees presently available in the market

	Commercial name	Beneficial Microorganism and origin of the strain	Recommended crops
	M/s Codagu Agritech Pvt. Ltd, Kushalnagar, Karnataka		
1	Tricho Cap	<i>Trichoderma harzianum</i> (ICAR-IISR, CLT)	Cereals, vegetables, spices, fruits crops, ornamentals
2	Power Cap	<i>Micrococcus luteus</i> (ICAR-IISR, CLT) <i>Micrococcus sp</i> (ICAR-IISR, CLT) <i>Enterobacter aerogenes</i> (ICAR-IISR, CLT)	Black pepper, Vegetables
	M/s SRT Agro Science Pvt Ltd., Patan, Durg, Chhattisgarh		
1	Azoss Caps	<i>Azospirillum brasilense</i> (NCIM 5135)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals
2	Aceto Caps	<i>Gluconacetobacter diazotrophicus</i> (NCIM 5348)	Sugar cane, Sweet potato, sweet sorghum
3	Rhizo Caps	<i>Mesorhizobium mediterraneum</i> (MCC 2495)	Leguminous crops
4	Zinc Grow Caps	<i>Bacillus spp</i> (IARI, New Delhi)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals
5	P.S.B plus Caps	<i>Bacillus megaterium</i> (NCIM 5472)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals
6	Potash Grow Caps	<i>Bacillus decolorationis</i> (ICAR-IARI, New Delhi)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals
7	Azoto Caps	<i>Azotobacter chroococcum</i> (MCC 2351)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals
8	NPK Grow caps	<i>Azotobacter chroococcum</i> (MCC 2351) <i>Bacillus megaterium</i> (NCIM 5472) <i>Bacillus decolorationis</i> (ICAR-IARI, New Delhi)	Cereals, vegetables, spices, trees, beverages, fruits crops, ornamentals

tonnes (Metalaxyl mancozeb formulation) in spice crops alone. The technology also reduced need for consumption of chemical fertilizers to the tune of 3169 tonnes of inorganic NPK nutrients in spices. The avoided environmental cost from avoided use of fungicide and chemical fertilizers is not explicitly considered herein.

- The novel encapsulation technology has been non-exclusively licensed to firms for production of encapsulated microorganisms (biocapsules) or use in crop production.

Licensing of encapsulation technology for commercial production

The technology has been licensed to two companies:

- M/s Codagu Agritech Pvt. Ltd. Kushalnagar, Karnataka
- M/s SRT Agro Science Pvt. Ltd, Patan, Durg, Chhattisgarh.

Revenue generated by the licensees (₹/year)

- M/s Codagu Agritech Pvt. Ltd. Kushalnagar, Karnataka: ₹ 3.0 crores/year
- M/s SRT Agro Science Pvt. Ltd, Patan, Durg, Chhattisgarh: ₹ 10.2

crores/year

Amendment to the Fertilizer control and inclusion of encapsulated microorganisms (biocapsules) in the Gazette of India

(Extraordinary, Part 2-Section 3-Sub section (ii) dated 01 December 2018)

- Following the success of this breakthrough technology, a significant development has been the amendment of the Fertiliser (Inorganic, Organic or Mixed) (Control) Order (FCO), 1985, namely Fertiliser (Inorganic, Organic or Mixed) (Control) (Fifth) Amendment Order, 2018, which came into force on the date of its publication in the Official Gazette (01 December 2018) and inclusion of encapsulation technology in the revised order.

Biocapsule value chain development for external marketing

- Another major watershed has been the development of value chain based on encapsulation technology wherein our licensee SRT Agro Science has signed MOUs with:
- NAFED (National Agricultural Co-operative Marketing Federation of India Ltd, New Delhi) for sale of Biocapsules through their marketing channel to various states of India.
- MAIDC (Maharashtra Agro industries Development Corporation Limited, Mumbai) for marketing biocapsules in Maharashtra.
- Paramparagat Krishi Vikas Yojna (PKVY) and ATMA schemes for large scale distribution through this Govt. Scheme by SRT Agro Science Pvt. Ltd.

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Know Krishi Unnati Yojana

The *Krishi Unnati Yojana*, a central sector scheme, is envisaged as umbrella programme for focusing on food security, by merging schemes on Soil-health Card, Integrated Scheme on Agricultural Co-operation and Agricultural Marketing, National Mission on Agriculture Extension, Horticulture Development, Price Stabilization Fund, National Mission on Sustainable Agriculture and other programmes.