

SeedPlus – eco-friendly cultivation methods for high-quality crop yields

Biodegradable seed coating for effective seedling protection and supply

While germinating, seeds must be supplied with sufficient water and protected from herbicides, as undisturbed crop development is key to ensuring stable and high yields. As part of the SeedPlus project, researchers from three Fraunhofer institutes have developed a biodegradable seed coating that features integrated water storage capacity and protection from herbicides to facilitate high germination rates.

Herbicides that are used to control weeds can affect seedlings and disturb the growth of sensitive crops. In addition to this, germinating seeds are particularly vulnerable to a lack of precipitation. The months of March and April were often extremely dry in Germany in recent years, causing seedlings to wither before they were able to establish. Fraunhofer researchers want to counteract this: As part of the SeedPlus project (see below), the Fraunhofer Institute for Microengineering and Microsystems IMM, the Fraunhofer Institute for Chemical Technology ICT and the Fraunhofer Institute for Molecular Biology and Applied Ecology IME have developed a seed coating that is designed to ensure a stable yield, even in adverse environmental conditions. Their approach is low in resource consumption, environmentally friendly and sustainable.

Unique feature: coating with combined protection and support function

Two key functions are combined in the SeedPlus coating and incorporated in the encapsulation: a support function for improved water management (water storage function) and a coating that protects the seeds against herbicides. Natural formulations based on natural polymers ensure that the seeds are constantly supplied with moisture during the germination phase, even when water is scarce. "The coating evenly releases the water to the seedling in a targeted manner. Its special feature is its ability to store extraordinary amounts of water, and that is an advantage in periods of drought," explains Anna Musyanovych, a research scientist at Fraunhofer IMM. At the same time, the selective membrane, which includes adsorbent materials such as activated carbon, protects the seedlings from herbicides without impairing germination or growth. The multifunctional coating allows for reduced use of plant protection agents and improves conditions for cultivation in regions with limited rainfall. "The coating is made of multiple layers of varying thickness that encapsulate the seeds. The shape and size depend on the seed type used, and the coating can be adjusted to the seeds' requirements and produced at scale," says Alexander Dresel, a research scientist at Fraunhofer ICT. "We use different encapsulation processes, depending on the seed type."

The fluidized bed process allows for precise layer thickness control, making it particularly well-suited for sensitive seed types. In this process, the seeds are suspended in the fluidized bed by means of a flowing gas stream while they are sprayed with the coating materials. In the drum coating process, the seeds are tumbled in a rotating drum while the coating materials are added gradually. "This process leads to even coating of the seeds and is a good choice for mass production," Thomas Heintz from Fraunhofer ICT explains. For coating smaller seeds, the research scientists at Fraunhofer ICT rely on the wet chemical surface method, in which the seeds are immersed in the coating structure that is then allowed to drip off.

Sustainable agriculture: microplastic-free seed coating

Conventional seed coatings frequently contain synthetic chemical components, which are considered microplastics. The Fraunhofer researchers have replaced these synthetic polymers, which can have an adverse impact on the environment, with ecologically harmless, natural formulations. Philip Känel, a research scientist at Fraunhofer IME in Münster, explains: "We are relying exclusively on natural organic and inorganic materials. We perform systematic tests with different combinations of materials, including polysaccharides, proteins, rubbers and porous inorganic materials such as activated carbon, to determine the most efficient compositions." The SeedPlus coating takes effect directly on the seed, which means that water and protection are provided exactly where they are needed, enabling a reduction in the amount of pesticides used.

Outdoor and greenhouse testing

The researchers conducted tests with Russian dandelion and sugar beet seeds both in greenhouses and under outdoor conditions to verify that the combination of protection function and water storage actually works. The impact that different formulations and compositions have on the seeds' germination capacity was examined, among other things. Compared to untreated seeds, the germination rate achieved with coated seeds was up to 58 percent higher. Other aspects, such as suitability for storage of coated seeds and compatibility with common sowing techniques, were also considered.

To be able to make reliable statements concerning ecotoxicity and degradation behavior of the coating materials during the material development stage and to identify any environmentally relevant risks, the researchers at Fraunhofer IME have also established a screening platform for assessing the innovative seed coatings. Before producing the encapsulated seeds, the researchers examine the individual components of the seed coating in terms of their ecotoxicological impact on model organisms of the aquatic and terrestrial environment to confirm their environmental harmlessness. To rule out potential long-term exposure, these tests also included an assessment of the individual components' degradability. "The sustainable design of our seed technology allows us to contribute to a reduction of environmental pollution and to support environmentally friendly, future-proof agriculture that achieves high yields," Känel says.

SeedPlus project

The project partners' tasks:

- Fraunhofer ICT, Pfinztal (encapsulation, coating structure and function)
- Fraunhofer IMM, Mainz (material development and coating technology)
- Fraunhofer IME, Münster location (functional evaluation of seed coatings and establishment)

- Fraunhofer IME, Schmalleberg location (environmental assessment of new testing and assessment strategies concerning environmental compatibility of the newly developed product)



Fig. 1 Seed coating with combined support and protection function © Fraunhofer IMM



Fig. 2 Dandelion seeds in alginate capsules produced using the dripping process © Fraunhofer ICT



Fig. 3 Germinating seeds © Fraunhofer IME

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