Trends in Plant Science

CellPress

Opinion

Seed Coating: Science or Marketing Spin?

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Seed coating is the practice of covering seeds with external materials to improve handling, protection, and, to a lesser extent, germination enhancement and plant establishment. With an annual value exceeding US$1 billion dollars, this technology is mostly the preserve of the private research sector, with few links to the scientific community. Here, we analyse the science and industry of seed coating and its contribution to seed establishment and plant performance. We posit that a closer collaboration between academia and industry is critical to realising the potential of seed coating both as a tool for enhancing plant establishment in the face of the challenges posed to agricultural systems and to propel the multibillion-dollar global push for ecological restoration of degraded ecosystems.

Trends

Artificial coating of seed is used to improve handling and for the delivery of protectants, symbiotic microorganisms, micronutrients, soil adjuvants, germination promoters, growth regulators, and colours.

The private sector owns and controls most of the technology, with the bulk of the expertise and capacity residing in a few multinational companies that have limited research connection with academia.

The research effort of industry is focussed on protective treatments (e.g., insecticides and pesticides), seed bulking, and embellishment for marketing purposes. The deployment of phytoactive promoters is rarely reported.

Seed coatings are mostly applied to crop and vegetable varieties. Despite the global push for ecological restoration, the scientific community rarely considers seed technologies for use on native species and there is no recorded interest from the corporate sector in restoration.

What Is Seed Coating and Why Is It Done?

Almost a century old [1], the practice of seed coating has become the mainstay for many of the horticultural and crop industries worldwide, with a global value estimated at US$53.76 billion/year in 2014[i]. Seed coating is the process of applying exogenous materials to the surface of the natural seed coat. This practice is used to modify the physical properties of seed [1,2], and for the delivery of active ingredients. The physical modification of seed aims to improve seed handling through standardisation of seed weight and size [3]. In some cases, where the aim is to reduce friction and improve flowability, the alteration of seed morphology is minimal, but for small (e.g., begonia or tobacco), expensive, or morphologically uneven seeds, a thicker coverage is often applied. The artificial coat is frequently used as a carrier for a variety of active ingredients.

With the introduction of seed-coating technology in developing countries, the global market for the materials alone (polymers, colourants, and bulking agents) that are used in seed coating is expected to reach US$1.63 billion/year by 2020[ii].

Currently, seed coating is performed almost exclusively on crop and vegetable varieties and the application of this technology to wild plant species for ecological restoration, whose market is estimated at US$18 billion/year [4], has been rarely explored by the private companies involved in the development and application of seed coatings.

The Case for Expanding Seed-Coating Technologies to Wild Species

Seed-coating technologies have been developed on crop and vegetable species for the most part, and, to a lesser extent, on seeds of turf grass, pasture, and flowers. The application of coatings to native species for ecological restoration has received little attention, with only sporadic evaluation in the scientific literature [5–7] and, so far, this field remains overlooked by the major agrochemical and seed technology companies. Yet, seed is fundamental to meeting global restoration targets, such as the rehabilitation of 150 million ha of degraded land by 2020, which is one of the United Nations (UN) sustainable development priorities[iii]. With

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the success rate of seedling establishment in restoration programs generally < 10% [8,9], the scope for seed improvement of native plant species is vast.

There is a pressing need for new approaches to seed-based restoration and seed-coating technologies could be key to improving seedling establishment [10], plant growth [6], and the restoration efficacy of native seed, most of which is collected from wild sources and represents a finite resource not to be wasted [11].

If the UN goals for ecological restoration are to be met, it is time to forge enhanced links between private and public seed technology research efforts. The development and commercialisation of seed-coating solutions for the emerging restoration ecology market could represent a major area of business for seed technology and agrochemical corporations, improve their environmental credentials, and provide new opportunities to deliver on their stated social obligations.

Equipment, Materials and Biological Effects

It is common for studies of seed coating published in the scientific literature to have outsourced the coating process to private seed companies (Box 1), meaning that the specific details of the application technologies and materials are not disclosed. Where academia has performed seed coating independently (without industry participation), simplified small-scale approaches (e.g., laboratory mixers or shakers, manual coatings, seeds shaken in plastic bags, or experimental technologies, such as liquid nitrogen [12], seed moulding [13], and seed extrusion [7]) in preference to the industrial standards (Figure 1, Key Figure) (Figures S1 and S2 in the supplemental Information online). The dissimilarity in the equipment used and the difficulty in accessing information on materials and methods are indications of the scarce transparency of industry. This lack of disclosure limits the capacity for independent scientific evaluation of the improvements delivered by seed coatings, and potentially compromises the critical analytical processes that could improve the understanding and adoption of seed-enhancement technologies.

Nevertheless, the materials used in the seed-coating process can be broadly categorised according to their function as **binders** (see Glossary), **fillers**, and active ingredients (Box 2).

Box 1. Seed-Coating Equipment

The rotating pan was the first machine used for seed coating and derived from a patent lodged at the end of the 19th century [55]. It comprises a round pan, usually inclined, on a rotating motorised pivot. Seeds are placed inside the pan and, while the pan is rotating, liquids are applied with a spray nozzle and powders are added through a hopper or by manual dusting. Rotating pans are mostly used to form pellets and rely on a slow rotating motion (5–35 rpm depending on diameter) [24] and the gradual addition of materials to increase pellet size [56]. The friction of seeds tumbling on each other is responsible for the spherical shapes produced and acts to smooth the external pellet surface. The process is followed by size sorting with sieves, and then drying [57]. A low-cost alternative to the rotating pan used in some studies is a cement mixer [58]; this may have application in developing countries with limited resources.

The fluidised or spouted bed apparatus, originally conceived in 1970 for drying solids [59], was first adapted for seed coating in 1975 [60]. This apparatus is cylindrical, with seeds subjected to a constant subfloor airflow that is adjusted to enable the seeds to remain buoyant in the air [57]. A spray nozzle atomises the coating liquid or slurry towards the suspended seed mass. This process is used for film coating and superficial encrusting, but is not feasible for pelleting.

A machine that allows for both film coating and pelleting is the rotary coater or rotor-stator. It comprises a cylindrical drum, with a concave disk at the base, whose rotation causes the seed mass to move in a regular flow along the walls of the drum. A smaller rotating disk that is responsible for the atomisation and projection of liquid or slurry to the rotating seed mass is usually attached to the drum lid and suspended in the middle of the drum [3,7].

These three systems are standard in the seed-coating industry and are integrated into many seed treatment plants to allow for automated procedures and for continuous batch applications. Due to the high number of variables involved, including the material combinations, machine tuning, and seed morphological differences, it is not always feasible to rely entirely on automated systems and the 'art and craft' of an experienced operator is often required to ensure the quality of the final product [57].

Glossary

Binder: a liquid with adhesive proprieties used to provide structural support and retention of active ingredients.
Dust-off: the release of dusty material from the surface of treated or coated seeds as a result of mechanical stresses and frictions during handling and sowing.
Encrusting: a coating process whereby powder and liquid binders are applied to the seed, causing a significant increase in weight and volume without altering the original seed shape.
Filler: a powdery, inert material used to increase seed shape and size.
Film coating: the application of a thin layer of material onto the seed surface. Weight gain, shape, and size modification of the seed are limited.
Hydrogels: polymers with hydrophilic structures that allow for the absorption and retention of a large amount of water.
Pelleting: the application of sufficient material to significantly modify seed morphology into a flowable spherical or ovoid shape; the most conspicuous of the coating treatments available.
Protectants: various active ingredients aimed at protecting the seed from seed or soil-borne diseases and threats, such as nematodes, bacteria, fungal infections, predator insects, and competing plant species.
Phytoactive compounds: active ingredients that promote germination, enhance seedling emergence, survival, and growth, and provide resistance to biotic and abiotic stresses.