IMPACT

IMPROVING CROP SEED QUALITY AND SEEDLING PERFORMANCE

The Seed Biology Place
www.seedbiology.eu

ROYAL HOLLOWAY UNIVERSITY OF LONDON

BBSRC

KWS

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Impact Objectives

- Provide up-to-date information about the mechanisms underpinning dormancy, germination, longevity, vigour and other key seed quality traits
- Integrate knowledge from distinct fields to improve crop seed quality and enhance seedling performance in stressful environments
- Collaborate with the seed industry on developing novel assays to enable breeding and on improving storability and refining seed priming technologies

Seeding knowledge

__Gerhard Leubner__ provides an insight into the __The Seed Biology Place__ website, a highly respected global resource, and discusses the __Group for Seed Biology and Engineering's__ invaluable ongoing research

Why is it essential to increase knowledge about seeds?

Seeds are at the beginning and the end of all important food chains that are central to human existence. In order to improve crop seed quality and seedling performance, a scientific understanding of seeds in all its aspects, from the fundamental to the applied, is needed. This requires interdisciplinary teamwork and collaboration with the seed industry for which my Seed Science Group has a longstanding track record. Seed and seedling traits and technologies are central to tackling the global and local challenges in food security and climate change.

Could you begin with an introduction to 'The Seed Biology Place'?

My research, teaching and outreach website 'The Seed Biology Place' (www.seedbiology.eu) is one of the most visited seed science websites internationally. As well as delivering the key objectives, the website provides information about timely topics in molecular seed biology and biotechnology, and on the research conducted in my Group for Seed Biology and Engineering at Royal Holloway University of London, UK. It also links to our publications which include internationally-recognised original articles and reviews on seed biology and engineering. Since I launched 'The Seed Biology Place' website in 2000 it evolved together with my seed science research in Basel (Switzerland), Freiburg (Germany), and now at Royal Holloway University of London. The website is recommended by NetWatch of the Science Magazine, by WebAlert and by the International Society for Seed Science (http://seedscisoc.org).

What are some of the key research threads currently underway by your Group?

Our Group for Seed Biology and Engineering at Royal Holloway University conducts fundamental and applied research using multidisciplinary approaches and by integrating results from the distinct method levels. Current postdoctoral and PhD student projects relate to the three key research threads in my laboratory. Firstly, research into fundamental mechanisms underpinning seed germination and seedling establishment as related to climate change and adaptation to stresses and unpredictable environment. A second research key thread is into the mechanisms of weed seed dormancy and germination which is also important for developing new weed management strategies. The third key research thread in my laboratory is impactful research into crop seed quality and technology to enhance seedling performance of agricultural and horticultural species.

How does this research deliver innovative agri-tech solutions for primary crop production?

Our research goes beyond the state of art to deliver innovative agri-tech solutions for primary crop production with a strong focus on the most vulnerable early stages. To achieve this we integrate distinct disciplines and methods such as molecular ecophysiology, stress modelling, seed technologies, transcriptome sequencing, and biomaterial (biomechanics) and electrical (such as gasplasma) engineering. To deliver innovative agri-tech solutions for primary crop production we collaborate with the seed industry, investigate the underpinning mechanisms of their seed technologies and develop novel assays to support breeding seed quality and seedling vigour. Our fundamental and applied research converges at the seed as a multi-purpose delivery system for agricultural technology, leading-edge science, innovative engineering, and sustainable solutions for global and regional challenges.

Looking ahead to the next five years, what do you have planned for 'The Seed Biology Place'?

The plan is to update and expand the presented information on crop seed quality and seedling performance on the website. This will also be instrumental for my Group and for our wide network of collaborations from academia and industry. My plans are to further strengthen this teaching and research focus area at the School of Biological Sciences and to tackle challenges which need further understanding of seed traits and technologies. I especially want to expand our seed priming, pelleting and biomechanics expertise and equipment.

Improving crop seed quality and seedling performance

*The **Group for Seed Biology and Engineering** at the **Royal Holloway University of London** is conducting world-leading seed and biotechnology research and unearthing important discoveries in the field of seed germination and technology*

With his solid track record in leading interdisciplinary and integrated projects into molecular seed and seedling research Professor Gerhard Leubner is an international leader in the field seed biology and is working to deliver novel technologies aimed at improving the yield potential of plants. He is Chair of Plant Biochemistry and Leader of the Group for Seed Biology and Engineering at Royal Holloway University of London (RHUL) and an expert in seed science, with more than 25 years' experience in in the field. His renowned and respected 'The Seed Biology Place' website is among the top-10 in the field across the globe.

INNOVATIVE SEED TECHNOLOGIES

Leubner's Group is focused on improving crop seed quality and seedling performance, which the researchers are achieving through fundamental and applied research using multidisciplinary approaches, a highly collaborative approach and state-of-the-art equipment and novel methodologies. 'High quality of commercial seed is achieved by a combination of breeding and innovative seed technologies. Seed enhancement technologies such as priming, improve vegetable, flower and sugarbeet seed performance. This leads to rapid germination, enhanced vigour and uniform seedling establishment even upon abiotic stress,' he states. 'Seed treatment technologies refine the seed with added values including coatings and pellets. The pellets aid drilling and may contain additives such as fertilisers and crop protection chemicals and biologicals such as plant hormones, allelochemicals and beneficial microbes.'

According to Leubner, high seed quality achieved by breeding and seed technology is the cornerstone for maximum yield potential. Seed priming, which is applied by the seed industry to sugarbeet, flower and vegetable commercial seeds to remove dormancy, enhance germination speed, and to improve seedling uniformity and performance even upon stress, is one modern seed technology used to enhance seed quality. 'While seed priming is positive in improving these seed properties and thereby performance in the field, it is on the other hand connected with additional costs, often compromises seed storability and over-priming can lead to problems in seedling establishment,' Leubner explains. 'The global seed market is characterised by competition between companies based on selling the best seed quality for their customers. Seed companies are therefore interested in further improving their crop-specific seed priming protocols. This requires understanding the underpinning mechanisms of the seed priming technology.'

UNDERSTANDING SEEDS

The key objectives of the Group's research are to: understand the underpinning mechanisms of seed vigour to improve seed germination, seedling uniformity and establishment in stressful environments; prevent seed vigour loss and ageing during post-harvest seed storage; develop novel assays for quantifying seed vigour and to enable breeding increased seed vigour and longevity; improve the biomechanical and biochemical properties of natural (endosperm, seed and fruit coats) and artificial (pellets) seed covering layers; and further improve the seed priming technology with novel environmentally friendly methods and additives. They have multiple strands of research underway to fulfil these objectives, including: ERA-Net for Coordinating Action in Plant Sciences (ERA-CAPS) European Consortium SeedAdapt; AgriTech Catalyst Early Stage Feasibility Study with Elsoms Seeds; Biotechnology and Biological Sciences Research Council (BBSRC)-funded projects 'Roles of Proanthocyanidins in Seed Dormancy' and 'Chemical Manipulation of Weed Seed Persistence'; Sugar Beet Seed Quality Projects with KWS Saat SE; and Allium Seed Longevity with Tozer Seeds.

Part of the researchers' work involves developing novel biomaterial engineering technologies, molecular and hormone analyses to improve vegetable seed priming and production in stressful environments using Dr Tina Steinbrecher's expertise in seed biomaterial engineering. The Group has established international recognition in interdisciplinary approaches which integrate seed biomechanics with molecular and hormone analysis.

UNEARTHING INSIGHTS

Leubner's Group is also working to provide important insights into the molecular mechanisms of how proanthocyanidins (PAs) – the brown/red pigments in the seed coats of broadleaf crop seeds (cress and other vegetables) and cereal grains (wheat, barley) – in seed coats interact with environmental conditions. 'This work is in collaboration with the group of Dr Andy Phillips at Rothamsted Research, Harpenden, UK, the longest running agricultural research station in the world,' Leubner reveals. 'PAs are proposed to determine the seed's dormancy and to provide germination adaption mechanisms to heat stress by acting seed coat impregnants. The biophysical properties of PA-containing as compared to PA-deficient seed coats will be directly analysed in this Biotechnology and Biological Sciences Research Council (BBSRC)-funded collaborative project. The obtained novel insights will contribute to strategies for mitigating the increased vulnerability of wheat to pre-harvest sprouting (PHS) in Europe.'

Developing a sustainable and mutually beneficial collaboration with partners from industry and academia is crucial for our interdisciplinary projects

The Group's sugarbeet quality research projects, which are funded by KWS Saat SE, Einbeck, Germany, investigate the mechanisms underpinning the seed priming treatment to improve seedling abiotic stress tolerance, identifying genetic factors and develop novel vigour assay important for early sowing, and investigating pericarp mechanics and pelleting mass. 'Dr Michael Ignatz in my Group is an expert for seed priming and seedling performance upon stress,' states Leubner. 'The Seed Science group at RHUL has longstanding experience in collaborating with the seed industry to improve various seed technologies.'

CRUCIAL COLLABORATIONS

Multiple, longstanding collaborations with industry have been invaluable to the success of the research, as Leubner states: 'Developing a sustainable and mutually beneficial collaboration with partners from industry and academia is crucial for our interdisciplinary projects. For the seed priming and pelleting technologies the seed companies provide their applied expertise and the seedlots to the projects,' he says. The Group's industry collaborations include KWS Saat SE, AgriTech Catalyst- and BBSRC-funded collaboration projects with the UK vegetable breeding companies Elsoms Seeds (Spalding) and Tozer Seeds (Cobham) for vegetable seeds and Azotic Technologies (Nottingham) for novel seed technologies with beneficial microbes to improve cereal grains. 'Azotic Technologies has identified a natural nitrogen fertiliser technology which we aim to deliver to agriculture via the seed,' Leubner explains.

They also have important academic collaboration partners, which provide analytical expertise and engineering tools. 'To develop a novel seed technology based on gas plasma treatment we collaborate with electrical engineers at Loughborough University, UK. Our hormone analysis is conducted from samples which were prepared by our metabolomics collaborators at Olomouc University, Czech Republic,' Leubner says. 'Depending on the project we have an established network of academic partners with the required complementary expertise.'

INSPIRING WORK

This Group aims to go beyond the multidisciplinary to deliver an interdisciplinary approach. To do this, the researchers use modelling of seed and seedling responses to environmental factors, such as temperature and water availability, as the quantitative physiological framework. 'Results from molecular analyses, biomaterial or electrical engineering, agri-ecology and other science and engineering disciplines are integrated in this manner,' highlights Leubner. 'Beyond this, the wider integration of the research is achieved by a holistic view of the seed supply chain and its impacts on stakeholders at all points considering economic, political, and social drivers and challenges.'

A crucial element of their work is inspiring and training the next generation of plant scientists, which Leubner says is vital to addressing challenges in food security, adapting to and mitigating climate change, and protecting biodiversity. 'Seed science is central to tackle the global and local food security and climate change challenges. This requires interdisciplinary teamwork and making sure that education and training meets the needs of employers.' Looking ahead, the team intends to expand their research on seed interactions and to look at beneficial microbes in order to explore the potential of using novel seed technologies to deliver new quality traits to agriculture and horticulture in this area.

Project Insights

FUNDING

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PARTNERS

Royal Holloway University of London • Palacky University Olomouc (Czech Republic) • Rothamsted Research (UK) • KWS Saat SE Einbeck (Germany) • Elsoms Seeds (UK) • Tozer Seeds (UK)

SEED QUALITY RESEARCHERS

Professor Gerhard Leubner • Dr Tina Steinbrecher (Biomechanical Engineering) • Dr Michael Ignatz (Seed Priming Technology) • Dr Marta Pérez (Proanthocyanidins) • Dr Kazumi Nakabayashi (Dormancy) • Dr James Hourston (Seed-Microbe Interaction) • Giles Grainge (PhD student) • Matthew Walker (PhD student)

CONTACT

Gerhard Leubner
Principal Investigator

T: +44 1784443553
E: gerhard.leubner@rhul.ac.uk
W: http://www.seedbiology.eu/

PRINCIPAL INVESTIGATOR BIO

Professor Gerhard Leubner, Chair of Plant Biochemistry and Leader of Seed Science Group at Royal Holloway University of London, has made important discoveries in the field of seed germination and technology. He has more than 25 years' experience in seed science and is the corresponding author of one of the top-most cited seed reviews of the last decade. Leubner is the coordinator of the ERA-CAPS European Network Project Consortium 'SeedAdapt', and the Principal Investigator of several BBSRC, Innovate UK, and Industry-funded awards. He has a solid track record in leading interdisciplinary and integrated projects into molecular seed and seedling biology, and in collaboration with industry into crop seed technology, vigour and weed control.

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