NMR and MRI Technology Identifies Factors in Seed Germination

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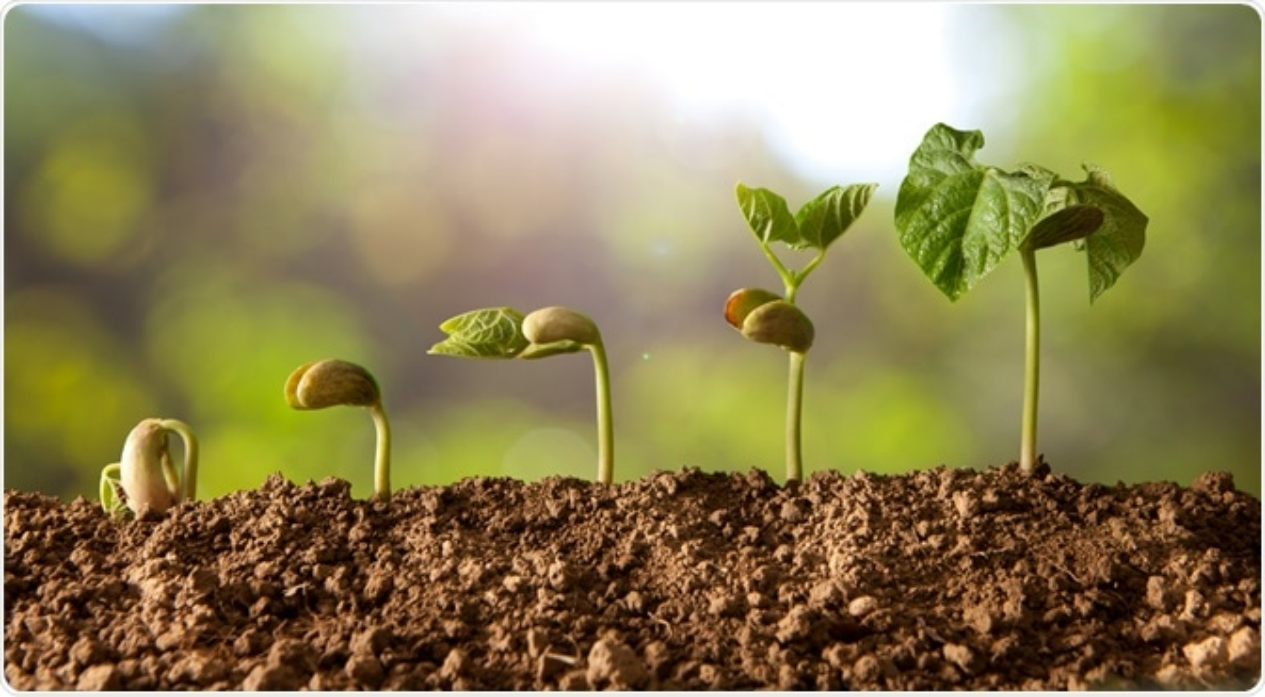
Seed germination, which is the essential first step toward crop establishment, begins with water uptake into the seedling. The term "seed imbibition" represents this process of water uptake and is followed by the seedling's protrusion from the root, or "radicle" tip.



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Plant biologists in the biotechnological industry find the study of seed germination an important element in understanding the development of plant life, in turn helping food and botany scientists ultimately improve agricultural and food production via biological and technological means.[1,2]

A large proportion of seed germination study focuses on the exogenous—or moisture and oxygen availability—and endogenous—or genotype, hormones, and dormancy—components which affect germination timing and rate.[3]

Many of today's investigators are seeking new strategies for control over this process in order to increase seed germination and subsequent plant yields.

Hopefully, this understanding and the application of this knowledge may provide more food for the growing population, with the potential to improve quality of life in developing countries.

NMR for Study of Seed Germination

Nuclear magnetic resonance (NMR) is a noninvasive imaging technique that has been consistently used to monitor the physical and chemical factors of seedlings and living plants.[4] The utilization of this technology, which depends upon the magnetic moment of the nuclear spin instead of radiation at high energy, has provided greater insights into seed germination in previous studies.

Studies are needed, however, to monitor post-water-uptake events and to examine the metabolic occurrences associated with restarting of the embryo.

Bruker AVANCE NMR Studies Seed Germination

A study by Munz et al, which utilized the 500 MHz Bruker AVANCE (11.7 T) superconducting magnet imaging system, investigated the necessary cues involved in embryo restarting in *Brassica napus* (rapeseed).[5] Specifically, researchers of this study examined the entrance of water into the seed as well as the water's pathway to seed tissues.

Study Strategy

Functional magnetic resonance imaging as well as the Bruker AVANCE system helped to analyze the germination process directly, from the movement of water and the processes of respiration and carbon metabolism to the final stages of seedling establishment. During the analyzation of the mature dry seed, the investigators used the Bruker AVANCE 750WB (17.6 T) to obtain data for time lapse movies.

Overall, investigators utilized a holistic *in vivo* strategy to demonstrate the association between the entry and categorization of water availability, chemical and metabolic occurrences, and structural changes which naturally occurred during the germination process.

In this holistic approach, the researchers combined noninvasive functional magnetic resonance imaging (MRI) with computer-aided seed modeling, fluorescence-based respiration mapping, and Fourier transform infrared microscopy.

Frequency-selective excitation pulses were applied consecutively at the water and lipid frequencies. This strategy enabled researchers to gain signal from the water while providing additional relaxation time to the spins of the lipids.

The spatial and temporal resolutions allowed the investigators to track water uptake as well as lipid distribution during the seed's structural changes. In addition, computer modeling facilitated visual representation of the data obtained from the Bruker system.

In combination with long-term monitoring of seedling germination with the Bruker device, the investigators used mapping of the seedling's oxygen consumption with a fluorescence-based system. A Fourier transform infrared (FTIR) microscope allowed for visualization of the metabolites' distribution and facilitated a quantitative analysis of biochemical components for the study of carbon metabolism restarting during germination.

Findings

According to the researchers, noninvasive Bruker AVANCE NMR technology represented the primary means of investigation for germination. The Bruker AVANCE system implemented actively shielded imaging gradients in addition to a custom-designed Helmholtz resonator. Imaging also enabled simultaneous observance of seedling fluid (water) as well as lipid components.

Researchers placed seeds in dark 5 mm NMR test tubes with either water or agar at 20°C to test germination of the rapeseed. The investigators noted that 2% agar resulted in good seed-to-exterior contact and helped reduce seed displacement throughout the NMR study period. In addition, the agar facilitated good water and oxygen supply during long-term germination monitoring with the Bruker AVANCE.

In summary, the researchers of this imaging analysis of the rapeseed were able to obtain visualization of the endospermal lipid gap. In the seed, sugar metabolism as well as utilization of lipid components were found to be

associated with the period of tissue rehydration. Overall, imaging with the Bruker AVANCE allowed direct analyzation of spatial aspects of essential occurrences leading to germination in the oilseed rape seeds.

Additionally, the Bruker imaging system demonstrated that the rapeseed features uneven swelling of each seed component during imbibition. Once imbibition is achieved, the volume of the seed rapidly increases, represented by a 6-fold increase in total water content. According to the investigators, the imaging study provided excellent insights into how the structure of the seed "predetermines the pattern of water intake, which sets the stage for the orchestrated restart of life."

The Bruker AVANCE NMR

Bruker BioSpin's AVANCE NMR technology provides high-speed imaging and pure frequency generation. The AVANCE III is specifically designed to offer high-speed RF and data generation (event time of 25 ns) with a scalable transmitter and several receiver channels. To learn more about this system and how it can apply to various scientific and medical research purposes, visit Bruker BioSpin today.

References:

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Last updated: Aug 28, 2018 at 12:29 PM

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