Leibniz Institute of Plant Genetics and Crop Plant Research (IPK)
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When things get tight: How does the embryo in the rapeseed react to mechanical constraints?

Press Release

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Gatersleben, 25.10.2024 **The initial free expansion of the embryo within a seed is at some point inhibited by its contact with the testa, resulting in its formation of folds and borders. Mechanical forces and constraints affect not just the embryo's shape but also its development and metabolism. An international research team led by the IPK Leibniz Institute has now investigated the basics of the embryo's reaction to mechanical stress in oilseed rape. The results were recently published in the journal "New Phytologist".**

In 2021, the Nobel Prize in Physiology or Medicine was awarded for elucidating the biology of mechanosensors. These discoveries revealed how mechanical forces generated by touch influence tissue differentiation and morphogenesis in animals and humans. Plants use similar means to sense mechanical forces, but the role of biomechanics and mechanosensory proteins is less understood. This particularly applies to embryogenesis.

In a project funded by the German Research Foundation (DFG), an international research team led by the IPK has investigated the biomechanical restrictions and their effects on embryogenesis in oilseed rape (*Brassica napus*), an important oil plant. The initially free expansion of the embryo is inhibited at a certain point by contact with the seed coat. This leads to the formation of folds and borders.

It turned out that embryos do not simply follow an intrinsic differentiation programme, but are forced to adapt to the space available for growth. "This is done by modulating both cell proliferation and central metabolism. This affects not only the final shape and size of the embryo, but also its progress towards maturation, and thus the accumulation of storage oils and proteins", says Dr. Hardy Rolletschek, first author of the study which recently has been published in the journal "New Phytologist".

The project, led by Dr. Hardy Rolletschek and Dr. Ljudmilla Borisjuk, head of IPK's research group "Assimilate Allocation and NMR", used magnetic resonance imaging, a method familiar to many in medicine, for non-destructive and dynamic analysis. This method, modified at the IPK for the study of plants, was combined with computer graphics simulations to model embryogenesis and seed growth. In order to gain deeper insights, the researchers expanded the spectrum to include methods for immunolabelling, flow cytometry and transcriptome, proteome, lipidome and metabolome analysis. The work relied on close collaboration between three IPK research groups and colleagues at Leibniz University Hannover and Brookhaven National Laboratory (USA).

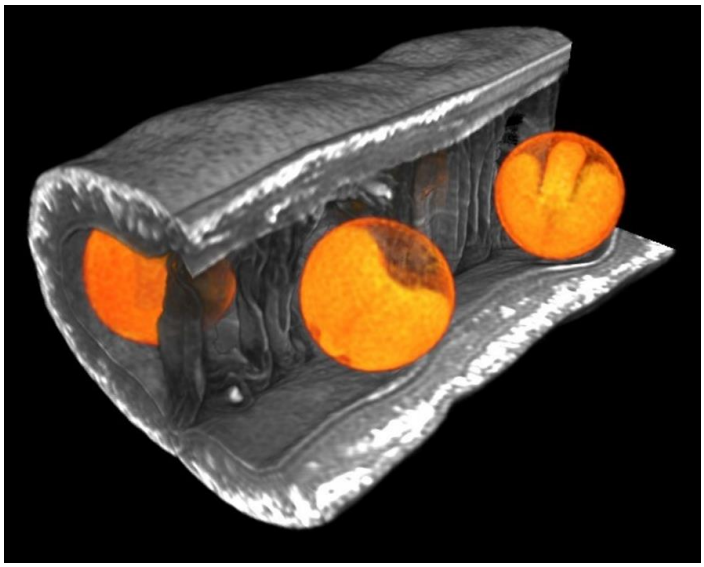
"Our research helps to explain long-standing observations by plant breeders of variations in relevant seed traits induced by environmental perturbations", says Dr. Ljudmilla Borisjuk. To put it simply, if the pod and/or seed is small in early spring due to poor growing conditions on the parent plant, the embryo inside the seed and the seed itself will be smaller as a result. "The embryo can apparently sense the space provided by the enveloping structures (silique, seed coat, endosperm)", says the IPK scientist. The adjustments made ensure proper seed filling, maturation and ultimately successful germination.

The magnetic resonance imaging platform recently established at IPK was financially supported by the European Regional Development Fund (ERDF) and the Investitionsbank Sachsen-Anhalt.

Original publication:

Rolletschek *et al.* (2024): Mechanical forces orchestrate the metabolism of the developing oilseed rape embryo. New Phytologist. DOI: 10.1111/nph.19990

Photo (for free use):



The image depicts a virtual slice through a *Brassica napus* silique, showing the spatial arrangement of the seeds (in orange). The image was produced using magnetic resonance imaging (MRI).

The embryo is spatially constrained to develop inside the seed (endosperm and testa are semi-transparent), while the seed itself is additionally constrained by the covering silique walls. This arrangement generates some mechanical forces that ultimately feed back to the embryo, its growth potential and its metabolism.