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# Magnetic resonance imaging for short relaxation times applied to seed evaluation

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In 2021, the Global Domestic Product (GDP) share attributed to the agricultural sector increased by 8.36%, comprising 27.4% of the total Brazilian GDP. Moreover, Brazil ranks first globally in soybean seed production. (1) Seed quality is crucial for crop development, directly affecting productivity. However, current seed evaluation methods lack accurate and non-destructive identification of early-stage lesions. Magnetic Resonance Imaging (MRI) has been proposed to address this issue by enabling the observation of internal structures on a 3D scale. However, applying MRI to hard tissues such as seeds remains challenging due to water being confined to a bound phase, reducing water mobility and resulting in ultra-short relaxation times (T2  0.1 - 10 ms). Rapid signal encoding and acquisition are needed to produce images with short relaxation times, before signal decay. (2) Different techniques have been developed, including Fast Low Angle Shot (FLASH), Zero Echo Time (ZTE), and Sweep Imaging with Fourier Transformation (SWIFT), to produce high-resolution images for samples with short relaxation times. Commercial equipment limits user autonomy in MRI Method implementation and adaptability, with manufacturer updates and maintenance posing issues over time. For instance, older equipment may not easily support the implementation of newer fast imaging techniques. To overcome it, the CIERMag Digital Magnetic Resonance Spectrometer (DMRS) addresses limitations in existing equipment, offering freedom in Method development. It uses Field-Programmable Gate Array (FPGA) technology with proprietary synthesized digital hardware subsystems. CIERMag also developed user control software using the Python Magnetic Resonanc e Framework (PyMR), and a proprietary programming language, the F Language. (3) This research project aims to investigate the application of MRI and image segmentation techniques for evaluating mechanical injuries and damage inflicted on seeds by insects during field or storage conditions. To achieve this goal, ultra-short relaxation time image sequences are being implemented on the DMRS. Already implemented and in use in the DMRS using F language, the FLASH sequence along with a protocol for acquiring locator images across three orthogonal planes show preliminary results. Processing files were also developed for image reconstruction from sequence-obtained data. Images of soybean seeds with various damages were acquired using a commercial Bruker spectrometer and the FLASH sequence for comparison.

**Palavras-chave:** MRI; Short-relaxation-times; Digital-spectrometer.

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