Optical Coherence Tomography and Raman Spectroscopy Can Predict Germination of Cotton Seeds

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Many different techniques exist to optically study physiologically relevant parameters in biological samples, such as seeds, non-destructively. For example, optical coherence tomography (OCT) can be used to measure seed coat thickness non-invasively [1]. On the other hand, Raman spectroscopy can be used to assess physiological parameters *in vivo* in plants [2,3]. Vibrational spectroscopy is also routinely used to measure seed composition, however mostly the spectra measured from many seeds are averaged together to obtain robust results. One of the advantages of being able to measure physiological parameters of seeds non-destructively, is that this allows to grow the seeds and correlate the measured parameters with characteristics of the plant. When physiological parameters can be obtained from single seeds, this can be used to select seeds for better outputs at the single plant level. Examples would be that damaged seeds are expected to not produce a seedling, the hypothesis that seedlings grown from larger seeds are more resilient, and that seed composition influences seedling vigor.

Cotton is an economically important crop and grown on a large scale in the southern US. Cotton yield benefits from precision agriculture, with parameters such as local plant density being highly relevant, where areas with too high plant density and too low plant density negatively impact the yield. A statistically uniform and optimal plant density is attempted to achieve by measuring seed germination rates before planting, and adjusting the number of seed planted per unit area accordingly. Cotton seed germination rates can vary significantly. Results improve when the seed germination rate is higher, as local density variations are lower for higher germination rates. Hence, methods to identify non-viable seed are actively being pursued.

Visual (or machine vision) inspection of seeds, for example, can be used to detect and discard (exterior) damaged seed. Unfortunately, seeds without visible exterior damage may also be unviable (for example damage can be covered by anti-fungal coating), and these damaged seeds cannot be detected through visual inspection. To address this issue, we use OCT to assess sub-surface morphology, and Raman spectroscopy to assess seed composition. We found that both seed composition (measured with Raman spectroscopy) and sub-surface morphology (measured with OCT) influence seed viability, and that the assessment of both characteristics together can be used to identify non-viable seed. Specifically, we found that spatial variability of the Raman signal in the range of 1250–1350 cm^{-1}, corresponding to the internal parts of the seed, happens more often in non-viable seeds, and the presence of a pronounced non-scattering layer in the seed hull (found in the OCT measurements) happens exclusively in viable seeds. Machine learning can be applied to further improve viability predictions, and to automate seed selection using OCT and Raman spectroscopy.

References

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