Biospeckle Optical Coherence Tomography in monitoring the effect of micronutrient Zinc on *lentil* seed germination

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1. Introduction

Germination rate and biological activities of seeds under heavy metal stress are regulated depending upon the type of heavy metal exposed to seeds. The heavy metal accumulation on farmlands has been enhanced at an alarming rate owing to mismanagement and widespread usage of chemical fertilizer and pesticides with high contents of heavy metals. Moreover, the animal manure is being deployed for farmland as a fertilizer resulting significant increase of heavy metal accumulation, particularly Zinc and Copper. The abundance of Zn accumulation was found from hog (931.9 mg kg-1) and chicken manure (481.69 mg kg-1) influencing seed germination time or rate [1]. Furthermore, seed germination and dormancy have great significance to improve crop yield and quality through reliable seed screening process. Hence, we propose the use of biospeckle optical coherence tomography (bOCT) to study the germination of lentil seeds under the exposure of Zn, since bOCT takes very short time for observation compared with conventional measures. In previous studies, using bOCT, it was revealed that biospeckle contrast can affect the biological activity on the healthiness of plants [2,3]. Thus, two different concentrations, 0.75 and 1.5mg/L of Zn were used to test the germination rate of lentil seeds. In bOCT, the speckle contrast is calculated from x-z frames obtained over a period of seconds, and the dynamic variation within the seed is visualized. Here we compare the biospeckle contrast images obtained under different zinc concentrations.

2. Experiments and results

A schematic diagram of the spectral domain OCT set up is shown in Fig.1.

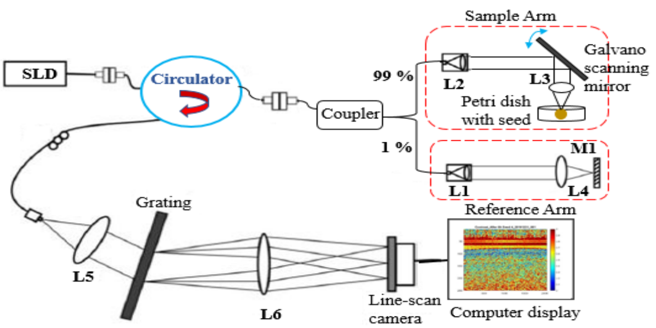

Fig.1. Schematic diagram of spectral domain bOCT.

A Super Luminescent Diode (SLD) having a central wavelength 836.1nm and a bandwidth of 55.2nm was used as light source. In order to reduce dispersion mismatch at both reference and sample arms identical lenses were incorporated. A coupler was used to divide the incident light power into 99% and 1% for sample and reference arms respectively. A 2D spectral image of 1024×2500 was acquired at an acquisition rate of 10 frames per second and 2.6 mW power was delivered to the lentil seed. The coefficient of biospeckle signal C_b is defined as, $C_b = \sigma_I / I$. Where, I and σ_I are mean intensity and standard deviation respectively, along the temporal axis at a point (x, t).

In the experiments, 6 seeds were placed on a filter paper in 9 cm Petri dishes. Thereafter, the Petri dishes were kept inside the growth chamber for germination under 27 ^{0}C, at a relative humidity of >70% and constant 4000 lux top illumination. At 24h after the start of exposure, seeds internal activity was observed by bOCT. A comparison of biospeckle contrast images before imbibition and after 24h imbibition to zinc is shown in Fig.2.

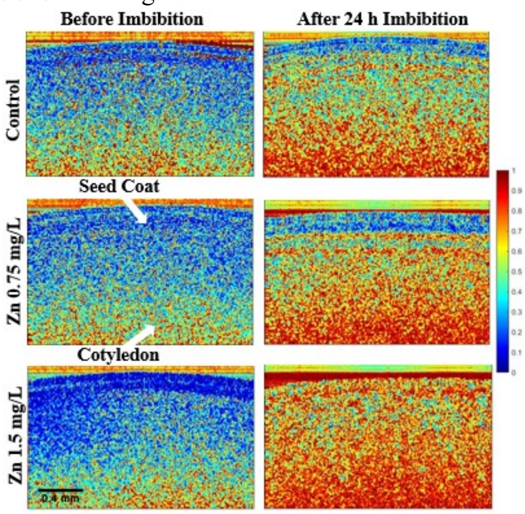

Fig.2. Comparison of bOCT images of lentil seed under Zn concentration of 0, 0.75 and 1.5 mg/L with left showing the images at 0h and right for 24h. Here blue and red respectively indicate the low and high speckle contrast. Scale bar represents 0.4 mm.

3. Conclusion

In this study, we proposed the use of bOCT to monitor seed germination under the exposure of heavy metal micronutrient Zinc. The biospeckle OCT images revealed that there is a higher internal activity as indicated by red within the seed compared to control after 24h exposure of Zn. Further, depending on the concentrations, there is clear difference in the internal activity of the seed. Hence, our results confirm the positive impact of Zn on seed germination. Further studies are required to monitor different kinds of heavy metal stress on seed germination.

References

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