High speed assessment of the effect of micronutrient Zinc and Alumina on *lentil* seed germination using Biospeckle Optical Coherence Tomography

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1. Introduction

There is increasing heavy metal accumulation on farmlands at an alarming rate owing to the mismanagement and the widespread usage of chemical fertilizers and pesticides that contain high concentration of heavy metals. The industrial use of alumina (Al_2O_3) nanoparticles (NPs) is rapidly increasing in agricultural products and cause various growth effects on different plant species [1]. Therefore, it is important to monitor the effect of heavy metal and alumina NPs for seed germination. Heavy metal stress has been found to influence the germination rate and biological activities of seeds [2]. On the other hand, seed germination and dormancy have great significance on improvement of crop yield and quality requiring reliable seed screening process. Here, we propose the use of biospeckle optical coherence tomography (bOCT) to study the germination of lentil seeds under the exposure of Zn and alumina. OCT is a non-contact and non-destructive technique visualizing that makes use of the speckles observed in OCT to monitor internal structural changes in-vivo [3]. Previous studies using bOCT revealed that biospeckle contrast could be affected by the biological activities within the plant depending on the healthiness of plants [4].

2. Experiments and results

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

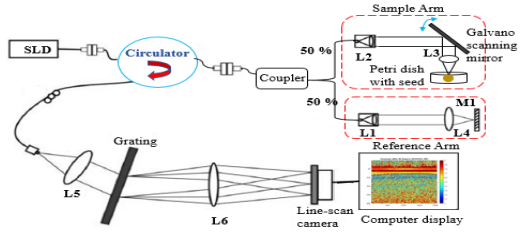

Fig.1. Schematic diagram of spectral domain bOCT.

In bOCT, the speckle contrast is calculated from x-z frames obtained over a period of seconds. Here we compare the biospeckle contrast images obtained under different zinc and alumina concentrations. The contrast 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 pixel of the image frame (x, z). A tomographic image of 512 (z) × 2048 (x) was acquired at an acquisition rate of 100 frames per second and 2.6 mW power was delivered to the lentil seed. In the experiments, two different Zn concentrations (0.75 and 1.5 mg/L) and 100 mg/L alumina particles having 2 and 0.2 μm in diameter were used to investigate effects on the germination of the lentil seeds. For each sample, 6 seeds (70 mg in average) were placed on a filter paper in 9 cm Petri dishes. Thereafter, the Petri dishes were kept inside a growth chamber at conditions of temperature being 27° C, a relative humidity of >70% and a constant illumination of 4000 lux. At 24h after the start of exposure to both zinc and alumina, biospeckle images were calculated. A comparison of biospeckle contrast after 24h imbibitions to zinc and alumina with control are shown in Fig.2(a) and Fig.3(a), respectively. The bOCT images revealed that there was a higher internal activity as indicated by red within the seed compared to control after 24h exposures of Zn and alumina. The speckle contrast (mean of six ROIs) of each bOCT images was calculated and obvious difference was observed for both zinc and alumina concentrations compared to the control (0.66 and 0.72 for highest concentration of Zn and alumina respectively) as shown in Fig.2(b) and Fig.3(b).

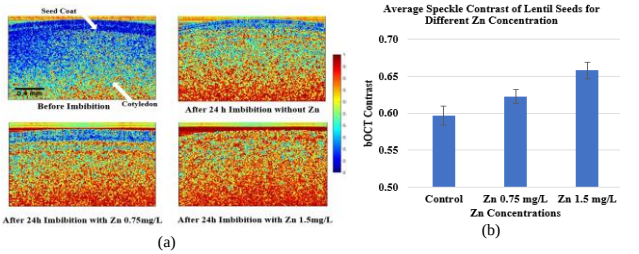

Fig.2. (a) Comparison of bOCT images of lentil seed for Zn concentrations. Scale bar represents 0.4 mm, and (b) Average speckle contrast of bOCT images.

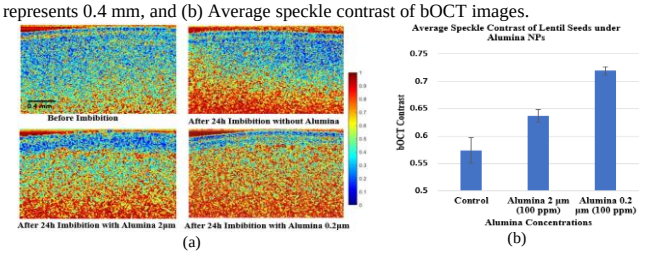

Fig.3. (a) Comparison of bOCT images of lentil seed under Alumina concentration. Scale bar represents 0.4 mm, and (b) Average speckle contrast of bOCT images.

3. Conclusion

In this study, we proposed the use of bOCT to monitor seed germination under exposure of Zinc and alumina micro or nano particles. The biospeckle OCT images revealed that there was a higher internal activity within the seed compared to control after 24h exposures of Zn and alumina. Further, depending on the concentrations and particle size, there is a statistically significant difference in the mean biospeckle contrast of the seed. Hence, our results confirm the positive impact of low concentration of Zn and alumina or NPs on seed germination due to enhance of energy metabolism. Further investigations are required on the biospeckles, to investigate the effect of increased micronutrient or NPs on seed germination.

References

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