Ultra short-term growth behaviour of plants under the influence of Cadmium using a highly sensitive interferometric technique, SIT

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1. Introduction

Cadmium (Cd) is a major environmental toxic heavy metal in soil, and can be absorbed in crop plants. Thus it could easily enter the food chain. In this study, a highly sensitive optical interference technique named as Statistical Interferometry Technique (SIT) [1] was used to measure the real time growth behavior of Chinese chives (*Allium tuberosum*) under Cd stress in the order of sub-nanometers and in the time scale of second. In SIT measurements, a special attention is paid to a fluctuation of ultra short-term growth rate, which is typically over 5 sec., in measurements of the in-plane displacement of the leaf. This nanometric fluctuation is an intrinsic property of the plant and is referred to as a nanometric intrinsic fluctuations (NIF) [2]. It was found that NIF reflects a biological activity in plants, and its standard deviation (SD) can be a measure of the plant healthiness.

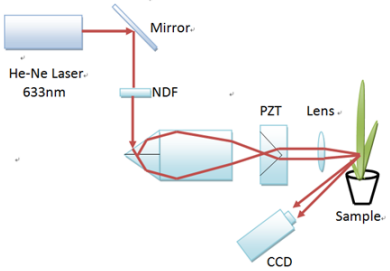

Fig.1 Schematic of experimental system

2. Experiments and results

SIT utilizes a complete randomness of the speckle field as a reference in a statistical sense. Figure. 1 shows the experimental system of SIT. A He-Ne laser beam of wavelength 633nm is divided into two beams by a specially designed prism. These two beams are focused onto the leaf by using lens. From illuminating point on the leaf, two independent random speckle fields are generated and randomly interfere each other on the observation plane. The random interference patterns are acquired by a CCD camera. The leaves of Chinese chives were used as samples, and in-plane displacement of the leaf was measured. The effects of Cd on plant growth and NIF of growth rate were observed for three days continuously by exposing their root to $CdCl_2$ solution. Figures 2(a)-(c) shows the growth rate fluctuations and SD of NIF under 0.1mM Cd concentration over three days (Fig.2 (d)). The period 'Before' and 'After' corresponds to Cd free condition and exposure to Cd solution, respectively. In Figure 2(d), a clear reduction can be seen in SD of growth rate after adding Cd. Figure 3 shows the results of normalized standard deviation (NSD) of growth rate for three days, where SDs were normalized by those before exposure. There was a clear reduction in NSD of NIF even at 6 hours as well as on second and third days, and reduction rates were 42% and 56%, respectively, for second and third days. On the other hand, it didn't show a significance difference under control condition.

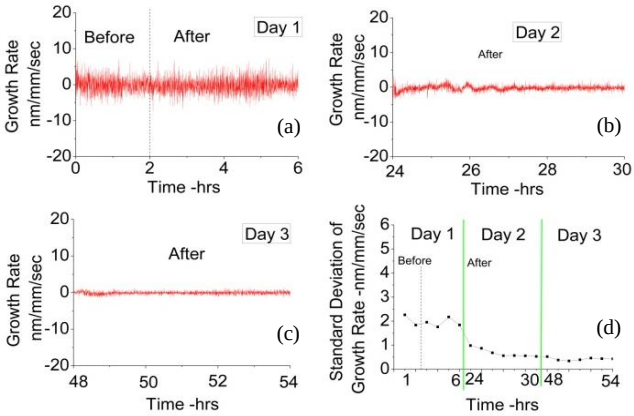

Fig.2 Growth rate fluctuations and SD of growth rate over three days under 0.1mM Cd concentration

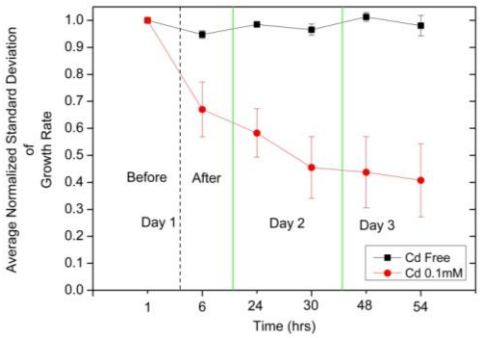

Fig.3 Normalized standard deviation of growth rate

3. Conclusion

In this study SIT was used for real-time monitoring of the growth dynamics of Chinese chives under Cd exposure. The results showed that SIT permitted to detect an immediate influence of Cd on plant. This implies that SIT is an attractive tool for the monitoring ultra short-term response of the plant under the influence of heavy metals. Our monitoring method based on NIF is sensitive enough to detect the influence of Cd on plants in a very early stage of heavy metal pollution.

References

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2. Thilakarathne BLS, Rajagopalan UM, Kadono H and Yonekura T, Spriner Plus, **3**: 89 (2014).