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Ultra-short term plant growth dynamics under cadmium stressusing Statistical Interferometry Technique

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Introduction

Heavy metals such as cadmium are life threatening substances and causing a serious soil pollution in many countries. Recently, an environmental technique called phytoremediation has been getting attention to solve the problem. The technique employs specific plants to absorb and remove the pollutant from the soil. In this study, an evaluation method of the influence of the heavy metal on plant growth using a novel optical interference method named Statistical Interferometry Technique (SIT), which was developed by the authors. The very short term growth dynamics under the effect of cadmium were measured for pea (*Pisum sativum* L.) in real time with very high sensitivity in the order of sub-nanometer. We have paid a special attention to Nanometric Intrinsic Fluctuations (NIF)[2] (Fig. 3) which are the fluctuations discovered in plants growth rate over very short periods, e.g, 5.5 seconds. The Standard deviation (SD) of NIF was found to be the indicator of the plant healthiness.

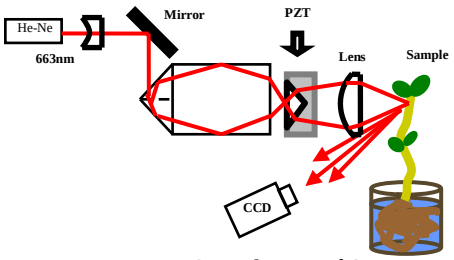

Figure 1　Optical setup of SIT

Experiments and discussion

Figure 1 shows the experimental system. He-Ne laser light of wavelength 663nm is divided into two beams and illuminate the plant stem at 16cm from the root of the pea whose full length is 18-20cm. The in-plane displacement of the illuminating point is measured by SIT algorithm. First, the root of the pea was placed in pure water for one hour, and then cadmium solutions were added into the water so that the cadmium concentrations were set to be 1g/L and 0.1g/L.

The growth behavior of pea for 1 hour before and 3 hours after adding cadmium solution of 1g/L concentration is shown in Fig.2, and has the nanometric fluctuation on it. Figure 3 shows the variation of corresponding short term growth rate. As can be seen from the figures, the SD of NIF together with the long-term growth rate over 1hour decrease after adding cadmium. Figure 4 shows the dependence of the long-term growth rate and the SD of NIF of the pea under the exposure of 1g/L and 0.1g/L cadmium solution. Here,the values were normalized by those before adding cadmium to eliminate the individual difference of the sample. In Fig.4 ,clear reductions can be seen in both of the longer growth rate and SD of NIF after adding cadmium. In addition, the reductions in both quantities become larger for the higher concentration of cadmium. The reduction rates of long-term growth rate were 7% and 51% for 1g/L and 0.1g/L concentrations, respectively at 3 hours after adding cadmium The reduction rates of the SDs of NIF were 61% and 77% for 1g/L and 0.1g/L concentrations, respectively.

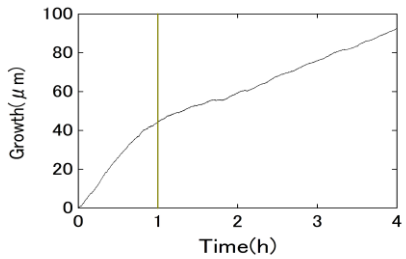

Figure 2

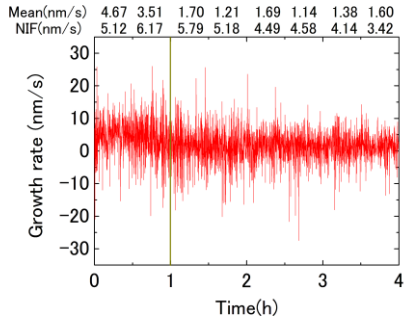

Figure 3

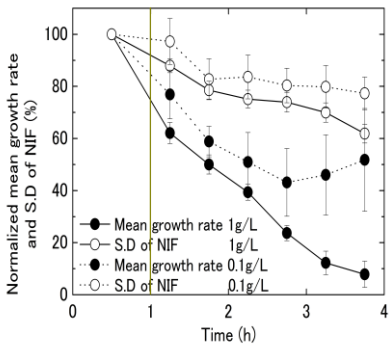

Figure 4

Conclusion

The imexperimental results indicate that cadmium has a significant influence on plant growth dynamics, i.e., long term growth rate and the SD of nanometoric fluctuation in ultra-short term. Both quantities could be useful and faster measures to select the proper cultivars and species for phytoremediation. Although the reduction of NIF seemed relatively smaller compared to long term growth rate, NIF has a practical advantage of generality that NIF can be observed irrespective to a part of plant body and the stage of its maturity.

References:

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