P-140

農林水産

TECHNOLOGY SHOWCASE

EIT Pot Sensor for Potato Tuber Visualization

■ Introduction

Potatoes (*Solanum tuberosum* L.) are the fourth most important food crop globally, playing a vital role in ensuring food security. Despite their significance, current approaches to monitoring below-ground biomass primarily rely on manual excavation of tubers—a method that is labor-intensive, time-consuming, and limited in sampling scale. Therefore, there is an urgent need to develop innovative, non-destructive techniques for assessing tuber development. In this study, we explore the potential of Electrical Impedance Tomography (EIT) as a non-invasive approach for monitoring below-ground potato growth. EIT utilizes differences in electrical conductivity between soil and plant tissues to generate subsurface conductivity maps. As proof of concept, we present a prototype system capable of detecting potatoes growing within ridges under field conditions, demonstrating the feasibility of non-destructive monitoring of tuber growth dynamics. Moreover, the proposed technique holds promise for broader application to other tuber and root crops, offering a novel pathway toward continuous, in situ monitoring of underground plant development.

■ Research Contents

1. EIT Pot Sensor Development

Two pots (with diameters of 24 cm and 16 cm) were each equipped with 64 electrodes connected through a series of custom-designed multiplexers and amplifier circuits to a Digilent Analog Discovery 2 device (Fig. 1a). Data acquisition and storage were performed using a program developed in the Digilent WaveForms software environment. A complete measurement cycle comprised 960 unique electrode pair selections, resulting in 960 complex impedance spectrograms. Each spectrogram contained measurements at seven frequencies ranging from 1- 100 kHz.

2. Potato tuber visualization

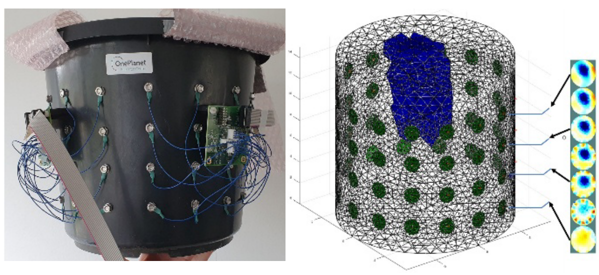
A 3D reconstruction model was made in EIDORS, an open-source toolbox for EIT reconstructions, because the impedance of a potato decreases with frequency whilst the impedance of the soil remains rather constant over this frequency range. A 3D polygon could be constructed as shown in Fig.1 (b).

3. Effect of soil moisture content on visualization

Visualization performance varied with both tuber size and soil water content. All tuber sizes failed to be visualized when the soil water content was below 25%. Medium and large tubers were successfully visualized when the soil water content exceeded 28%, and the clearest visualization was achieved at 37%. However, small tubers remained undetectable even at 37% soil moisture. When medium-sized tubers were successfully visualized, impedance distribution patterns were more distinct at frequencies between 2-5 kHz, whereas the effect of frequency was minimal in the case of large tubers.

■ Practical Application

This research demonstrated the potential of EIT as a non-destructive technique for measuring potatoes (as small as 3 cm) and with moisture content ranging from 10%-35%. By setting the sensors in the open-field, the possibility of utilization of this sensor in the open-field was explored. This technology holds promises for further development towards measuring tubers in other crops, such as sweet potato, taro, or carrots. However, while dragging the sensor on top of the ridges was not preferable for tuber crops, a new technique involving RF tomography is proposed as an improvement of the current studies. The research was carried out under the joint research between NARO and Wageningen University.



(a) (b)

Fig. 1. (a) A photo of the Impedance monitoring pot. (b) An example of the 3D Reconstruction of a potato using fdEIT from 1 kHz to 10 kHz. Multiplexers can be seen around the outside.

Njane Stephen Njehia, Joseph Piller, Yoshida Mitsuki, Jan Willem de Wit, Jindo Keiji. 2025. Engineering in Agriculture, Environment and Food (EAEF). Vol. 18 (1). In press.

代表発表者　**Njane Stephen Njehia**
（ンジャネ　スティーブン　ンジェヒア）

所　　属　**国立研究開発法人 農業・食品産業技術総合研究機構 農業情報研究センター AI研究推進室 確率モデルユニット**

問合せ先　**〒305-0856 茨城県つくば市観音台 1-31-1**
TEL：029-838-7168
Email: njane.stephen.njehia344@naro.go.jp

■キーワード： (1) Non-destructive Imaging
(2) Tuber development
(3) Tomography

■共同研究者： Joseph Peller[1], Mitsuki Yoshida[2], Jan Willem de Wit[3], Jindo Keiji[1]
[1]Wageningen University and Research, The Netherlands
[2]Hokkaido Agricultural Research Center, National Agriculture and Food Research Organization (NARO), Japan.
[3]IMEC OnePlanet, The Netherlands.