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Non-thermal plasma for germination enhancement of radish seeds

Khanit Matra*

Department of electrical engineering, Engineering faculty, Srinakharinwirot University, 63 M.7 Rangsit-Nakhonnayok road, Ongkharak, Nakhonnayok 26120, Thailand

Abstract

This paper is aiming to present the atmospheric non-thermal plasma for the germination improving of radish seeds. Plasma generation power and plasma irradiation time were studied in order to obtain the proper conditions for the germination enhancement of seeds. The growth rate was determined by measuring the length of root and dry weight of the plants treated by plasma jet. From the experimental results, it could be confirmed that plasma treatment could enhance the growth rate of radish seeds 9-12 percent of the dry weight of radishes, approximately.

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Keywords: non-thermal, plasma jet, germination enhancement, seeds ;

1. Introduction

Nowadays, non-thermal atmospheric gas discharge or plasma has shown great interest among scientists owing to its many advantages such as low temperature, scalable size, low operation cost, flexible operation, and high electron and reactive specie density. Non-thermal plasma has been principally used for surface modification because of its energetic electron and reactive species. Recently, non-thermal plasma has been promoted for applying in biotechnology, medical treatment, food preservation, and agriculture. This is due to the fact that non-thermal plasma does not cause thermal damage to the living organisms, and it is also a green technology[1,2].

Regarding the literature reviews of the seed growth enhancement by plasma treatment, the results show worthy outcomes; in addition, Thailand is an agriculture country[1,2,3,4]. Therefore, our research group has come across idea to develop and improve the agriculture technology by our non-thermal plasma jet model. In this work, the preliminary

* Corresponding author. Tel.: +662-649-5000; fax: +663-732-2602.
E-mail address: khanit@g.swu.ac.th

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results of seed germination enhancement by plasma treatment are present. The radish seeds were chosen to study the effect of plasma treatment on seed germination. To obtain the proper condition for the germination enhancement of radish seeds, plasma generation power and plasma irradiation time were optimized. The growth rate of seeds was determined by measuring the length of root and dry weight of the plants treated by plasma jet.

2. Experimental set-up

2.1. Design of plasma jet model

The schematic drawing of the experiment set up for radish seed germination enhancement by plasma treatment is illustrated in Fig. 1(a). The experiments were conducted in a room environment. Argon gas from a gas cylinder tank was controlled by a pressure gauge and fed through the plastic tube to the copper tube cathode. Plastic tube and diameters of 6.4 mm copper tube cathode were hooked together by the plastic cork on the stand and base. A 1.5 mm diameter copper rod was inserted into the center of copper tube cathode and was also hooked by a plastic cork as an anode. The copper rod tip was shorter than the end of copper tube by 1.75 mm, approximately. The 10x15x20 mm^3 acrylic box as a plasma reactor was worn at the end of the copper tube cathode. A positive source voltage (V_s) of 0-30 kV was applied to the anode by a dc high voltage power source (Matsusada, AU-30P10) through 5 or 7 mega ohms ballast resistors. The characteristics of discharge voltage and current can be monitored by an oscilloscope (SIGLENT, SDS2304). A high voltage probe (Pintek HVP-28HF) was connected across two electrodes to observe the discharge voltage (V_d). The copper tube cathode was grounded through a 22 ohms monitored resistor to detect the discharge current waveform (I_d).

2.2. Plasma Treatment

In this research, the radish seeds (*Raphanus sativus*); which is one of the industrial crops of Thailand, were chosen to study the effect of plasma treatment on seed germination since the physical characteristics of the radish seed is small shaped and thin skinned. The radish seeds were obtained from the Ongkarak market. When the Argon gas was fed through the tube and the source voltage was supplied to the system sufficiently high enough, the plasma jet was generated between the tips of copper tube and ejected to the acrylic box. From the experimental results, it shows that 4 liters per minute (LPM) of Argon gas was most suitable for plasma generation for our system due to the lowest breakdown voltage and plasma irradiating area. Plasma generation power and plasma irradiation time were optimized to obtain the proper experimental condition for the germination enhancement of radish seeds. The plasma generation power was varied from 0 (the controlled condition), 90, and 140 watts. The 10 radish seeds per one experimental condition were exposed to plasma for 2, 4, and 6 minutes of plasma treating time in each plasma generation power. Plasma was generated at the source voltage (V_s) of 21.2, and 30 kV for 90, and 140 watts of plasma generation power, respectively. The characteristic waveforms of V_d and I_d at 90 watts of plasma generation power are present in Fig. 1(b). It should be mentioned here that in Fig. 1(b), due to the limitation of the high voltage probe, only the waveforms of 90 watts of plasma generation power are present. The discharge waveforms were in self-pulsing discharge mode which was suitable for seed treatment. The peak discharge current pulses were ranging from 0.0072 - 0.186 amperes with a life time of 45 micro second, approximately. The self-pulsing frequency was increased by increasing of the source voltage. The explanation of this situation is in[5,6].

After the plasma treatment process, 6 groups of treated radish seeds and 1 controlled group were soaked in the water for 2 hours. Seeds were cultivated in the dark of environmental room condition. The growth rate of seeds was determined by the length of root and dry weight of the radish sprouts. The radish sprouts were dehydrated at 105 degree Celsius for 3 hours by a universal oven (MEMMERT UM 500) and weighed by an analytical balance (Mettler Toledo PL303 Milligram Balance) after measuring the 7 day radish sprout root length.