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The effect of atmospheric plasma jet treatment on honeydew melon seed

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Abstract. Non-thermal atmospheric gas plasma is popular for its flexibility and inexpensive cost. NTP is used in food preservation, medical therapy, biotechnology, and agriculture. This study examines how atmospheric plasma jets affect honeydew seed germination, water intake, and growth. In this research, high voltage (1.0–1.4 kV) was varied at a certain frequency with Argon gas. Honeydew melon seeds were a plasma treat sample. Untreated and treated seeds were separated at first. The seeds were examined for a few days after plasma treatment with varying voltage and exposure times. Wider pores reduce contact angle and promote wettability. Optical Contact Angle (OCA) measured the water droplet contact angle. Finally, plasma- treated seeds were compared to untreated seeds to determine plasma's impact on seed quality.

1. Introduction

One of the most popular fruits in Malaysia is honeydew, a type of melon (Cucumis melo L.), a member of the Cucurbitaceae family. These fruits can be grown throughout tropical and subtropical areas. Globally, over the past ten years, the production of melons has steadily increased, reaching its present annual output level of approximately 31.2×10^6 tons [1]. Domestically, melons were grown on more than 6,000 hectares of land in 2015. Melon cultivation has been promoted due to its reputation as one of the most competitive fruits in both domestic and international markets [2]. Farmers require new information as well as technology linked to melon farming to remain competitive in the worldwide market.

Technology is a crucial component in farming operations. The technology index is significantly correlated with income and total output. Hence, income and overall productivity increase as technology usage increases [3]. There are several techniques that can be utilized to raise the germination rate to increase the production of high-quality honeydew. Seed treatment is one of the techniques. There have been many different seed treatment techniques developed, including bio- priming, film coating, slurry coating, pelleting, and plasma treatment.

Plasma technologies have been used to treat crops, seeds, and soil in a physical and/or chemically efficient and productive manner. Reactive oxygen and nitrogen species (RONS), changes in pH, electrical conductivity, and oxidation-reduction potential in the solution were all caused by the plasma. These remedies affect plant growth, seed germination, and agricultural yields [4].

A lot of research has shown that non-thermal plasma (NTP) has the potential to be an effective and ecologically friendly method for controlling plant pathogenic bacteria [5]. Plasma treatment alters the surface properties of seeds, resulting in improved seed wettability and water uptake, as well as higher germination Plasma uses in agriculture are categorized into

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two: preharvest and postharvest. NTP application in post-harvest procedures including food preservation and processing [6]. For the NTP's use in preharvest, however, there are only several studies known. Preharvest applications of NTP technology include seed sterilization, improved seed germination, and reduced pathogen invasion in soil [7].

There are several study using plasmas to treat crop to boost germination, growth, and physiological levels, leading to an increase in output such as wheat [8], safflower (*Carthamus tinctorium* L. *semen*) [9], wild asparagus, [10]. Several studies used plasma to treat sunflower seed [11], rice [12], and mushroom spawn [13]. The exposure of the seeds to these plasmas played a role in breaking dormancy as well as encouraging growth, resulting in higher yield.

In this study, the usage of atmospheric pressure plasma jet (APPJ) to treat honeydew seeds is to increase germination and surface morphological traits. As a result, both the germination rate of the seeds and their capacity to absorb water were evaluated on a laboratory scale.

2. Methodology

In this methodology include seed preparation, the Atmospheric Pressure Plasma Jet system design, the optical contact angle, and seed germination.

The seeds of the honeydew were acquired at the market. All the gathered seeds underwent thorough air drying. Only top-notch seeds were selected. The seeds are prepared by washing with clean water after being removed from the honeydew. Next, the seeds are dried overnight to prevent the fungus from growing on the seed. The seeds can be long lasted if there it was not affected by fungus. Then, the seeds were treated with plasma. The control variable for this experiment are varied voltages and variation of plasma exposure time. Five seeds were subjected to each variation in voltages at 1.0 kV,
1.1 kV, 1.2 kV, 1.3 kV, and 1.4 kV for a period of 10 seconds. Another five seeds were treated for plasma exposure time that varied from 10s, 20s, 30s, 40s, and 50s for a constant voltage of 1.4kV. Total of 50 seeds were treated while maintaining the argon gas flow rate at 100 standard cubic centimetres per minute (sccm).

Figure 1 shows the schematic diagram of experimental setup used in this study. An AC high voltage was supplied to the rod tungsten and the aluminum plate was connected to the ground. Multi gas controller will manipulate multi flow controller to allow desired flow rate of argon gas in this experiment. Next, the signal can be read using PicoScope Oscilloscope and viewed on the screen via PicoScope 6 software.

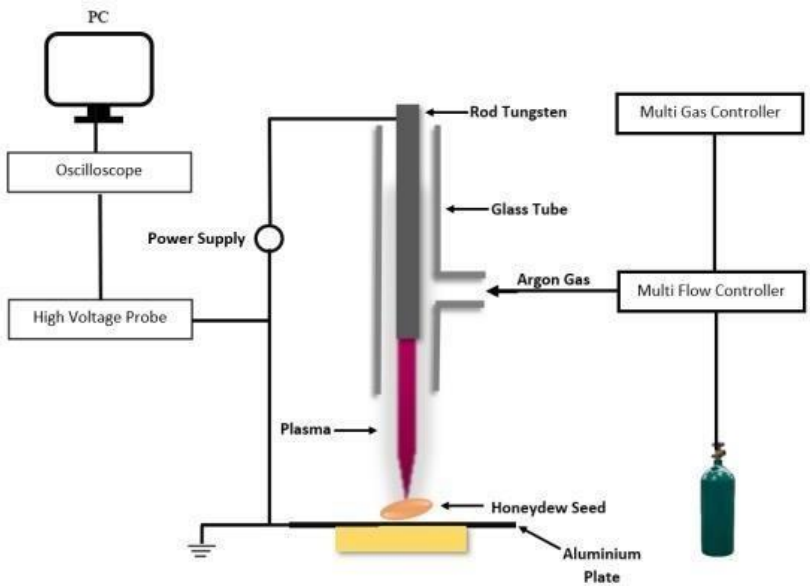

Figure 1. Schematic diagram of the experimental setup.

A mass flow controller (MFC) directs 100 sccm of argon gas from the gas cylinder into the plasma jet. A mass flow controller (MFC) device is utilized to measure and calibrate the flow of argon gas across a given flow rate range. The multi gas controller (MGS) is utilized to regulate gas flow rates. This device displays the actual flow rate utilized for the duration of the experiment. The wire that attaches to the end of the tungsten rod was linked to a high voltage power source, whereas the wire that attaches to the aluminium foil was grounded. During the experiment, the seed was placed on the aluminium plate and exposed to low-temperature plasma. Each seed was subjected to plasma at varying voltages and periods.

Next, optical contact angle (OCA) measurements were utilized to determine the wettability of treated and untreated seeds by measuring their contact angles. Lastly, all the treated and untreated seeds will be placed on wet cotton wool in the rectangular microwave food container to monitor its germination and seedling growth. The OCA 25 is a versatile measuring device that can analyze drop form as well as determine contact angles. With a high-performance camera that has a USB 3.0interface and a 6-fold zoom lens, it is possible to analyze even the quickest processes, as the device can capture up to 2450 frames per second. As a result of this, it is possible to determine with high precision the contact angles of adsorbing surfaces such as tissues or powders. After filling the syringe with water, the DISPENSER button was pressed, at which point a droplet of 1.00 microliters of water was dispensed onto the surface of the seed. After that, the measurement of the angle was taken at the point where the drop matched the location that had been determined by capturing the drop visualization.

Seeds that were treated by varied voltage (1.0 kV, 1.1 kV, 1.2 kV, 1.3 kV, and 1.4 kV) for 10 seconds each and varied plasma exposure time (10s, 20s, 30s, 40s, and 50s) for a constant voltage of 1.4kV. Both were treated with constant flowrate of 10 sccm. Those seeds were be placed on wet cotton wool in the rectangular microwave food container to monitor its germination and seedling growth. Lastly, the container was placed by the window to expose the seeds to sunlight.

3. Results and Discussion

3.1. The Seed Growth

The average length of root and stem of honeydew germination for eight days that were treated with different voltages are shown in Figure 2, while treated with different exposure time are shown in Figure 3 below.

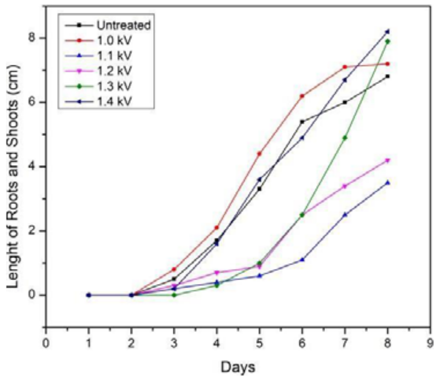

Figure 2. Germination of honeydew seeds within eight days with varying voltage.

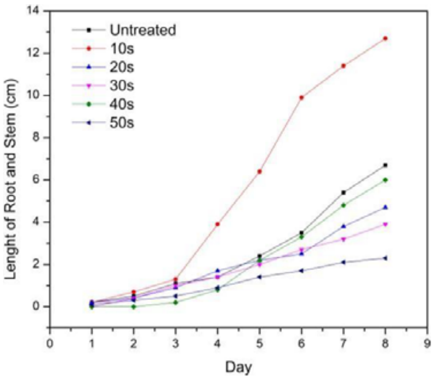

Figure 3. Germination of honeydew seeds within eight days with varying exposure time.

In Figure 2, approximately, most of the seeds began to germinate on the third day of germination, showing that the seeds treated with 1.0kV grew the longest, measuring 0.8 cm, while those treated with 1.3kV began to sprout on the fourth day. Up until the seventh day, all seeds consistently germinated. It was discovered on the eighth day that seeds that had been exposed to 1.3 kV and 1.4 kV were both longer than seeds that had been exposed to 1.0 kV, measuring 7.9 cm, 8.2 cm, and 7.2 cm, respectively.

Figure 3 shown that the findings revealed that all the seeds underwent germination on the third day, with the seeds that had been exposed for 10 seconds having the highest length (1.3 cm) and the seeds that had been exposed for 40 seconds having the shortest length (0.2 cm). All seeds uniformly germinate starting on the fourth day and continuing. On the eighth day, it became apparent that the seeds treated for 50 seconds had grown the slowest, reaching a maximum length record of just 2.3 cm, whereas the seeds treated for 10 seconds had reached a maximum length record of 12.7 cm.

The longer the seeds exposed to the plasma, the higher the chances the seeds will damaged. There have been some traces of burned on the seed surface that have been treated with longer time of treatment which can cause the slow germination of the seed.

3.2. Seed Contact Angle

(a) (b) (c)

Figure 4. (a) Contact angle of water droplet on untreated honeydew seed surface. (b) Contact angle of water droplet on treated honeydew seed surface at 1.4kV. (c) Contact angle of water droplet on treated honeydew seed surface at 10s.

After plasma treatment, both 10 seconds and 1.4 kV seeds have smaller contact angles in comparison to untreated seeds. This is because most of the water droplet has dispersed across the surface of the seed, as can be seen in Figure 4 (b) and 4 (c) in contrast to Figure 4 (a) which depicts a water droplet that has not spread significantly on an untreated surface. The surface of treated seeds has more and wider pores, hence their wettability are greater than untreated seed.

4. Conclusion

The treatments demonstrate that the optimal voltage for nonthermal plasma is 1.4 kV and optimal exposure time is 10s period. The seed germination rate for 1.4kV is increase 20.59% and for time treatment 10s increase 89.56% compared to untreated seed. The treated seeds significantly have good wettability which is more hydrophilic than untreated seeds. Adequate watering promotes rapid seed germination.

Compared to another study that used Dielectric Barrier Discharge Planar (DBDP) [14], it is more convenient and efficient to use Atmospheric Pressure Plasma Jet (APPJ) as in APPJ, the time treatment is shorter, and the power of plasma is higher. Furthermore, in DBDP, the plasma is not equally distributed onto the seed during the treatment because they been treated in bulk the same time, while in APPJ, the seeds are treated one by one.

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