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To cite this article: J Nantapan *et al* 2019 *J. Phys.: Conf. Ser.* **1380** 012131

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The effects of atmospheric plasma jet treatment to the germination and enhancement growth of sunflower seeds

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Abstract. Using the plasma technique, the sunflower seed was treated by means of argon plasma. The argon plasma was driven by high voltage DC pulse at 25 kHz. Plasma dissipated power was varied at 0.41, 0.51, 0.61 and 0.72 watts and argon gas flow rate was fixed at 4 liters per minute for 15 sec. The experiment analyzed the physical properties, chemical properties and growth rate. Concerning the physical properties, the morphology was checked via the contact angle and roughness by SEM. The chemical properties were analyzed via contact angle. The growth rate was checked using 4 processes: the 1st is the water uptake, the 2nd is germination count rate within 5 days, the 3rd is seeding length within 7 days and the 4th is dry weight of seeding with 80 °C in the oven for 24 hrs. The results show the contact angle of control is 41.08 degree. After treatment using plasma jet the contact angle decreased, henceforth the wettability increased. Using increased plasma power the surface roughness increased. The water uptake of plasma with dissipated power at 0.41 watts gave the best result. Following plasma dissipated power at 0.41 and 0.61 watts respectively the germination count rates are 68% and 56%. The seeding length as well as the dry weight decreased when the power increased.

1. Introduction

The sunflower (*Helianthus annuus* L.) is the center of medicinal values which is used as food and medicine worldwide. It is pharmacologically for various activities such as the anti-oxidant, anti-inflammatory, antitumor, antigen, antipyretic, astringent, cathartic, diuretic, antiasthmatic, stimulant, vermifuge and antimicrobial activities and antihypoglycaemic. Some of the welfares attributed to the sunflower and it's sprouts is that a collection of phytochemicals are present in this vegetable by food or via chemical interpretations. Especially sprout are consumed at the beginning of the growing phase, their nutrient concentration remains very high [1]. In naturopathy, sprouts have the medicinal benefits; they can be promoting health aspects and safety evaluation [2]. The U.S. Food and Drug Administration has published several recommendations to consumers regarding consumption of sprouts [3]. It has economical stimulants for the producer as well as wellbeing benefits for the customer. The atmospheric plasma jet add to stimulate the growth rate, without losing the health benefits, in this a situation benefitting not only the producer, the customer but also the pharmaceutical industry. The plasma jet able to enhancing the quantity and quality of sunflower sprout and also plasma technique processing are powerful techniques for sterilization, functionalization, inactivation



of enzymes, altering the hydrophilic/ hydrophobic properties and etching [4]. They are successful progress as key manufacturing technologies for a variety of industrial applications such as surface modification and biomaterial processes. The plasma jet is one types of cold plasma that could be easily operated at atmospheric pressure with variety species of gas, which is influent to the physical and chemical properties. In this research to studied this plasma jet effect to the sunflower.

2. Materials and method

The sunflower seed samples consisted of five groups; control group, Samples 1, 2, 3 and 4 and each sample group has 25 seeds. The samples are arranged on a glass plate. The argon plasma was driven by high voltage DC pulse at 25 kHz. Plasma dissipated power was varied at 0.41, 0.51, 0.61 and 0.72 watts and argon gas flow rate is fixed at 4 liters per minute and treated with time limits for 15 sec. The physical properties are observed with water contact angle. Growth parameters were studied by the water uptake, seed germination, sprouts length and dry weight.

2.1. Vegetal material

The common sunflower (*Helianthus annuus* L.) is a species of the Asteraceae family grown commercially worldwide offering a variety of nutritional and medicinal benefits. The sunflower seed and sprout contain valuable antioxidant, antimicrobial, anti-inflammatory, antihypertensive, wound-healing, and cardiovascular benefits found in its phenolic compounds, flavonoids, polyunsaturated fatty acids, and vitamins. These notable medicinal, nutritional, and culinary benefits have resulted in historical and growing popularity of the sunflower and its constituent parts worldwide.

2.2. Plasma jet source

In the plasma technique, the seeds were treated with the argon plasma. The argon plasma was driven by high voltage DC pulse at 25 kHz, plasma dissipated powers were 0.41, 0.51, 0.61 and 0.72 watts, respectively. The argon gas flow rate of 4 liters per minute through the capillary glass tube with diameter 0.5 mm as show in figure 1. The time is fixed at 15 sec in every sample.

2.3. Germination

The germination percentage reported indicates the proportion by number of seed which have produced normal seeding in temperature room, light/dark (12 hrs. /12 hrs.) within 5 days and record the number of germinated seeds every day on the respectively time frame. Calculation follows on this equation.

$$GR(\%) = \left(\frac{\text{Number of ger min ate seeds in 5 days}}{\text{Total number of seeds}} \right) \times 100 \quad (1)$$

Total weight and length of seeding were measured on day 5. Plant material for dry weight was dried at 80 °C for 24 hrs. and measured for dry weight. Vigor indexes I and II were calculated according to equation.

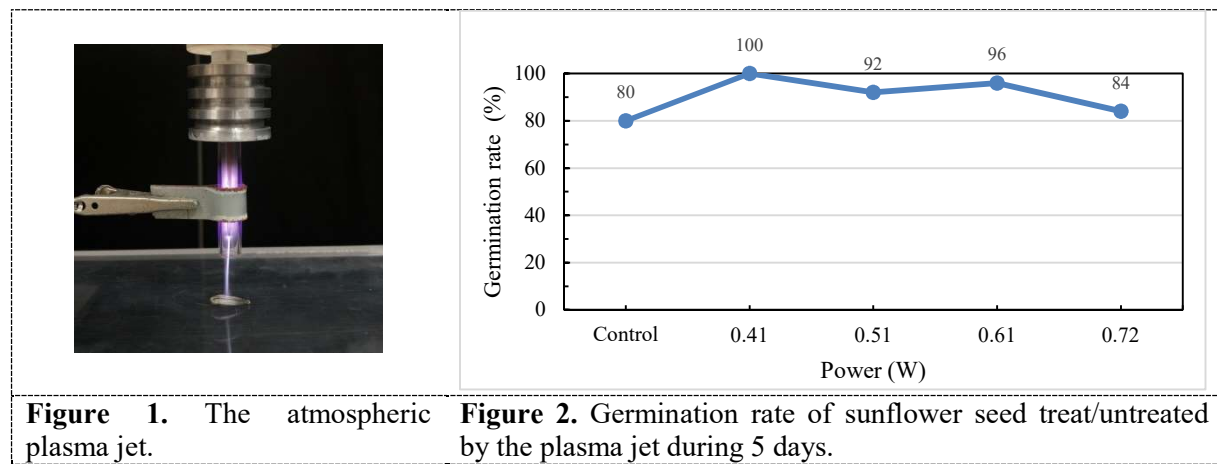


Figure 1. The atmospheric plasma jet.

Figure 2. Germination rate of sunflower seed treat/untreated by the plasma jet during 5 days.

$$VI = \frac{\text{Seedling length(cm)} \times GR(\%)}{100} \quad (2)$$

$$VII = \frac{\text{Dry weight of seedling(g)} \times GR(\%)}{100} \quad (3)$$

2.4. Seed imbibition

Dry seeds were weighed (m_o) and submerged under water on the plastic plate for 24 hrs. Every 2 hrs. seed was taken out of the water and dried with tissue paper and weighed (m_t). Percentage of water uptake was calculated for each time (t) as this equation.

$$\text{Water uptake}(\%) = \frac{m_t - m_o}{m_o} \times 100 \quad (4)$$

The static contact angles measurements employ the fundamentals of liquid spreading to determine the surface energy of a solid. The water contact angle was analyzed by a self-made static contact angles, detail of this was described elsewhere. Deionized water, DI droplets (3 μ L) were dropped on top of the seeds at room temperature. Fifth replicates of each condition of treatments were analyzed.

3. Results and discussion

3.1. Seed quality

Using the Ar gas plasma jet technique in this work, the power of the plasma are 0.41, 0.51, 0.61 and 0.72 Watts by fix the exposure time is 15 sec, which is the key factor for enhancing seed germination and plant growth or for controlling food surface microorganisms. The several beneficial radical doses showed a combination of argon gas and air with fixed time of exposure without provoking damage to the seed. The result found that all the plasma treatments had significant stimulatory effect on seed germination and vigor. The germination rate (GR%) increased when the exposure time increased; as shown in figures 2 and 3.



Figure 3. Sunflower seeds after treated/untreated by Ar gas plasma jet with 24 hrs. (a) Control (untreated), (b) 0.41 Watts, (c) 0.51 Watts, (d) 0.61 Watts and (e) 0.72 Watts.

3.2. Water uptake

The atmospheric plasma jet was treated sunflower seed, the result is the effects in the different power exposures with 15 sec. The result of 0.51 watts power plasma had the highest effect of water uptake. The result shown in figure 4.

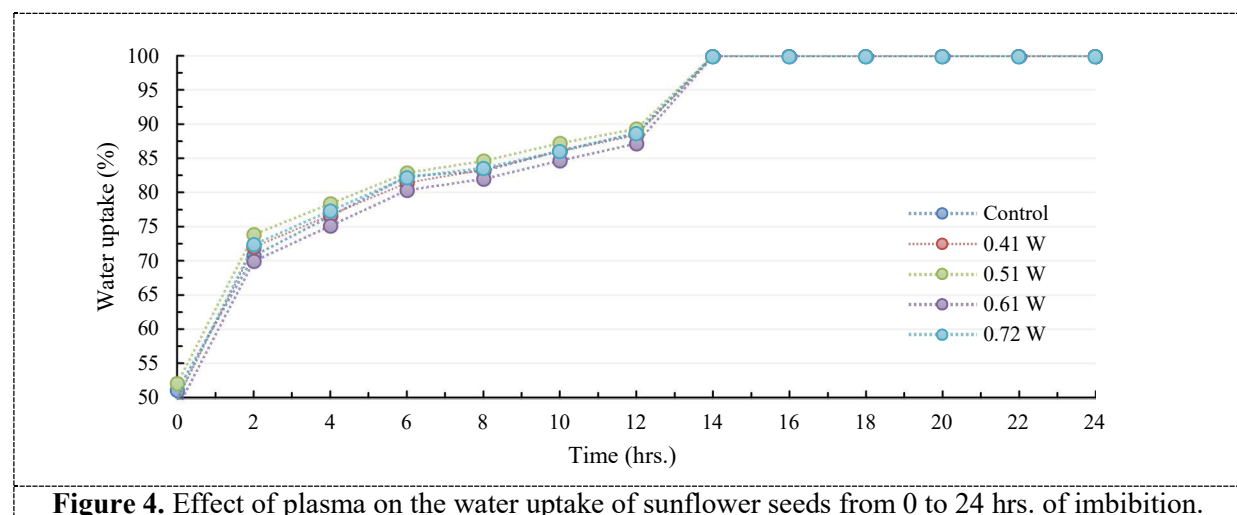


Figure 4. Effect of plasma on the water uptake of sunflower seeds from 0 to 24 hrs. of imbibition.

3.3. Germination and vigor

All the plasma treatments had a significant stimulatory effect on the germination and vigor. Indicating that with a greater exposure time of the plasma jet, the seeds germinate better and faster and produced longer and heavier seedling. The seed treated by 0.41 watts has highest value in length of shoot and root seedling. The results as shown in figure 5 are that all the growth in length of shoot and root seedling are higher when treated by plasma than the control, the maximum length being 12.88 at 8 day with power plasma 0.41 watts. The seedling weight and dry weight of sunflower seeds are also all higher when treated by plasma than the control. The maximum seedling weight and dry weight being 6.187 g as shown in figure 6. The effect of sample 1 treated with the power plasma 0.41 watts has maximum of seedling weight and dry weight.

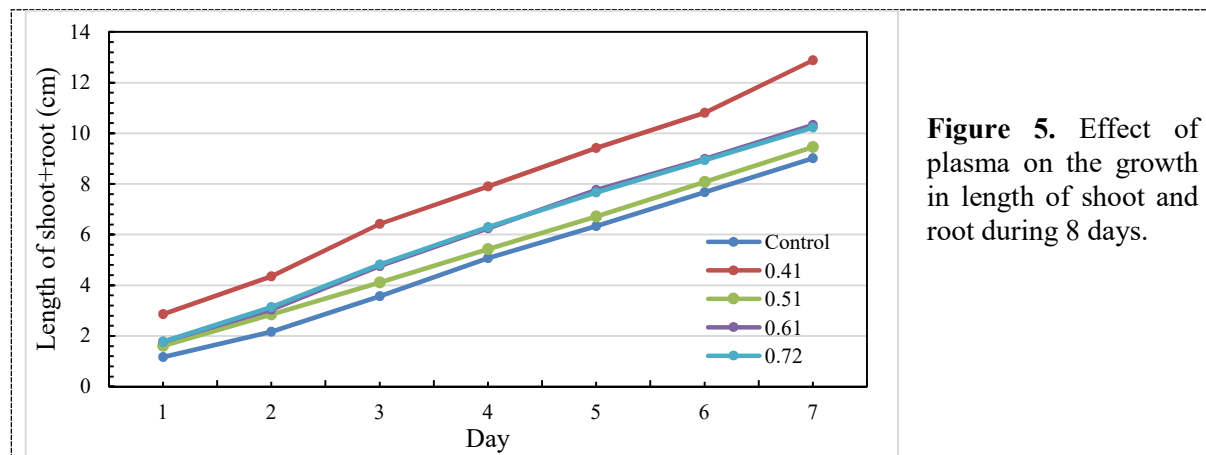


Figure 5. Effect of plasma on the growth in length of shoot and root during 8 days.

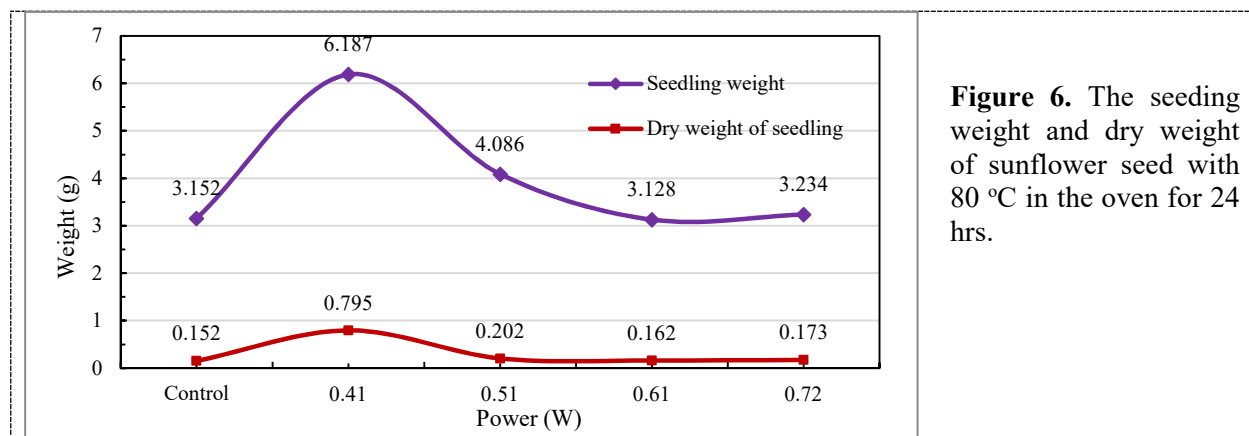
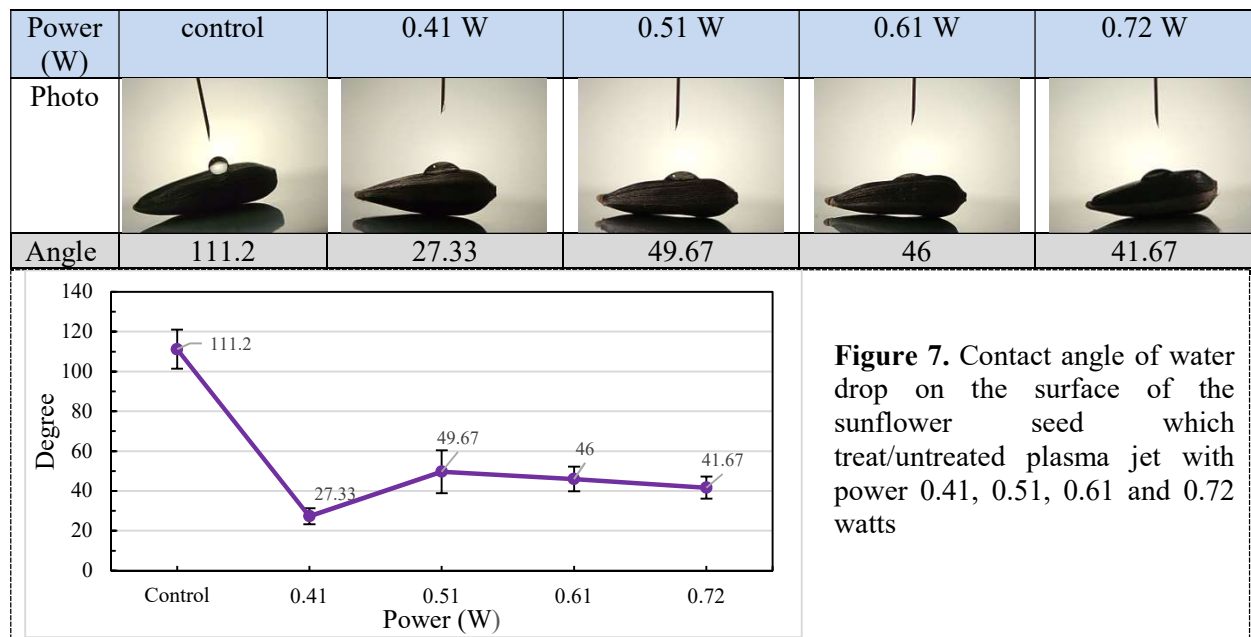


Figure 6. The seedling weight and dry weight of sunflower seed with 80 °C in the oven for 24 hrs.

3.4. Contact angle

The contact angle is the quality to its hydrophilic ability, which is relative to the germination seeds. The contact angle was measured when DI water was dropped to the 5 samples seed groups. The apparent contact angle of treated plasma is obviously smaller than the control as well as by the differential speed at which the drop is absorbed by the coat. The Flat water on the surface means that the polar and nonpolar surface energy increased being relative to the higher hydrophilicity properties as shown in figure 7.



4. Conclusion

Our study showed the effectiveness of atmospheric pressure plasma jet, operating at different power output on the sunflower seed, that improved seed health by the plasma produced ROS and RNS and provoked the oxidation lipids present in seed coats. Henceforth leading to promoted seed water uptake, which resulted in decreasing seed coats being hydrophilicity because the plasma has the sputtering interaction on the surface, then it has more roughness the water easily seep in to the surface. Following plasma dissipated power at 0.41 and 0.61 watts respectively the germination count rates are 68% and 56%. The 0.41 watts power output plasma give the best result in the enhancement of sunflower seed germination and vigor because this power is best for water uptake to sprout.

Acknowledgments

The authors are thankful for Plasma and Beam Physics Research Facility, Department of Physics and Materials Science, Faculty of Science, Chiang Mai University.

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