Germination enhancement of green bell pepper (*Capsicum annuum* L) by using non thermal argon plasma

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**Abstract.** An attempt to enhance the germination of green bell pepper has been tried by using dry processing non thermal (cold) argon plasma treatment. As an emerging non thermal technology, cold plasma could be used to give a pretreatment to a thermal-sensitive material, such as pretreatment to seeds of bell pepper prior to be planted in soil to understand the effect of this dry process during the germination period. In this experiment, the used argon plasma was generated by flowing argon gas with the rate of 2 L/min through a positively charged of stainless pipe at a distance of 15 mm from aluminum plate electrode. With an applied voltage of 9.8 kV (peak-to-peak) electrical energy from a high voltage AC power supply, argon plasma irradiation was employed to the bell pepper seeds for a predetermined period of time as pretreatment to the seeds during pre-planting. It was found that the temperature of the plasma never exceeded 35°C during the plasma irradiation to assure that no thermal damage occurred to the seeds. It was also confirmed from this study that by giving non thermal plasma treatment for 30 minutes to the seeds may enhance the germination of the bell pepper plants up to 90% in stem length and almost 2.5 times in root length compared to the pepper without treatment.

**Keywords:** Non-thermal plasma, seed germination, green bell pepper, agriculture.

1. **Introduction**

Nowadays, non thermal plasma that generated at atmospheric pressure becomes a great interest to be applied in various fields. Non thermal plasma technology can be utilized in industries to treat textile waste water, metal and plastic processing, exhaust gas and odor remediation, applied in various medical application, food bioprocessing and very recently as a source to treat agricultural seeds for...
stimulation of germination. Most of atmospheric pressure non thermal plasmas are in the form of corona discharge, dielectric barrier discharge (DBD), glow or filamentary discharge, plasma jet [1] and gliding arc discharge [2]. By generating in atmospheric pressure, non thermal plasma may offer many advantages like continuous and flexible operation, typical low cost dry processing and suits for treatment of thermal-sensitive material due to the discharge temperature which does not exceed 35°C.

Particular interest in plasma agriculture which could be referred to the utilization of non thermal plasma for the improvement of agricultural products, plasma treatment could be employed to promote seed germination, to stimulate plant growth as an alternative of nonorganic fertilizer and to improve the resistance to the plant disease [3]. Looking to the great potential offered by the non thermal plasma application in agriculture from literature reviews [4-7], our research group tried to investigate the positive effect or enhancement of green bell pepper seed germination after various duration pretreatment of the seeds by non thermal argon plasma at atmospheric pressure. The green bell pepper was chosen in this study because it has more attractive market locally and the market need of this typical vegetable continues to increase, particularly in big cities in Indonesia. It is generally known that for the establishment of pepper to grow, fast germination and vigorous early seedling growth are essential [8], therefore some method of seed pretreatment is needed. As a dry process, pretreatment by non thermal plasma to the pepper seed can be carried out as an alternative to the enhancement method of pepper seed germination under wet conditions, either by aqueous nanochitin suspensions [8] or by using hydro and osmopriming method [9].

2. Experimental

2.1 Material

Dry green bell pepper seeds (Capsicum Annuum L) were purchased from local market in Jakarta. The seeds were stored without any special treatment in an ambient air before utilized in these experiments.

2.2 Non thermal argon plasma treatment

Non thermal argon plasma developed in this system was generated under atmospheric pressure using a homemade high voltage AC power supply. The schematic diagram of pepper seeds treatment by using non thermal argon plasma can be seen at Figure 1 below.

![Schematic diagram non-thermal plasma treatment onto pepper seeds. Inset: plasma in action during seed treatment.](image)

A typical high purity Ar gas with the flow rate of 2 L/min was delivered through the 3 mm inner diameter of stainless pipe that connected to the positive charge of power supply. Argon gas was
chosen in this experiment due to its less expensive cost compared to the helium gas and the easiness to generate non thermal plasma in a moderate applied voltage. Applied voltage was measured by using a PD-28 high voltage probe with a 1000:1 attenuation ratio and the waveform signals were monitored with a DSO 5072P Hantek digital oscilloscope.

Pepper seeds are placed on aluminum plates at a distance of 15 mm from the end of the stainless electrode. Pepper seeds were irradiated by argon plasma for 15 and 30 minutes. Immediately after plasma treatment, all treated pepper seeds were taken and were put into 180 mm in diameter and 120 mm in height plastic container which has filled with fertilized soil. Seeds without plasma treatment were also planted as a control. Every day, the seeds were irrigated with 100 ml tap water. All of these experiments were carried out in a ventilated room with the temperature of 27-33 °C in which the samples were not directly exposed to the sun. From day 16, the germination was start to grow and the seedling shoot lengths were measured by using a digital caliper. At the end of the test, the pepper root length was also measured as a parameter of seed growth rate.

3. Result and Discussion

Non thermal plasma system for pepper seeds treatment was performed at atmospheric pressure and in ambient air using argon as the working gas. In these experiments, the pepper seeds were irradiated by typical argon plasma in the form of filamentary discharge. To generate this discharge, 9.8 kV of electrical energy from high voltage AC power supply was used as it was known from oscilloscope reading like depicted in Figure 2.

![Figure 2. Oscilloscope reading of the applied voltage used for non thermal argon plasma.](image)

During the treatments carried out in the range of 15 minutes and 30 minutes, observation result of the temperature shows that the argon discharge never exceeds 35 °C as measured by thermal imaging camera FLIR-TG165. It is clear that this dry treatment will have no influence in thermal damage on the seeds and the seeds still viable to germinate.

![Figure 3. The influence of Ar plasma treatment time to stem length of bell pepper](image)
The influence of seed irradiation time by non thermal argon plasma toward the stem length of bell pepper can be seen at Figure 3. It is clear that the non thermal argon plasma treatment on the pepper seeds gave an influence of germination enhancement of bell peppers which have higher rate of stem length than the control sample (0 min), especially after 18 days of cultivation.

All bell pepper seeds were germinated after 13 days of sowing the seeds into the soil. In case of the control pepper, initial growth of the seed was increase rapidly till day 17, followed by very slow of growth after that. On the other hand, the seed growth with 15 minutes argon plasma treatment gave almost a constant rate of pepper stem growth till the day of 21 followed by decreasing of the growth rate. Argon plasma treatment for 30 minutes gave a similar impact with the 15 min, except the measured stem length has higher results. From this experiment, 15 min argon plasma treatment to the seeds could improved the stem length of bell pepper up to 63% and 30 min argon plasma treatment could improved the stem length of bell pepper up to 90% compared to the untreated seed after 26 days of cultivation. At the end of the experiments the root lengths of all plants were also measured. Figure 4 shows the root length measurement of untreated seed and treated seeds after 26 days of cultivation.

![Figure 4](image)

**Figure 4.** The influence of Ar plasma treatment time to the root length of bell pepper

From Figure 4a, it can be observed that all the bell pepper’s roots were growing straight that may be due to the water absorption for initial growth and supported to hold the stem growth. Up to 26 days of cultivation, the untreated pepper seed case the root length was 22.3 mm, whereas on the case of the seeds that treated with 15 min argon plasma the root length could achieve 44.8 mm and the seeds that treated with 30 min argon plasma the pepper root length could reach as depth as 55.7 mm which is 2.5 times longer compared to the pepper root length without treatment. From the measurement of stem length and root length of the bell pepper in Figure 4b, it can be concluded that the seed pretreatment with the dry process of non thermal argon plasma could improve the germination rate of the bell pepper.

4. Conclusion

Non thermal argon plasma has been generated at atmospheric pressure with a voltage of 9.8 kV p-p (peak-to-peak) and successfully suitable for pretreatment of bell pepper seeds before planting in soil. During irradiation argon plasma with an object distance of 15 mm, the measured temperature did not exceed 35 °C that assured the seeds experiencing no thermal damage and was still viable to germinate. In the untreated pepper germination, the first 3 days of grow after day 13 was very rapid, followed by slow of growth after that period. In contrary on the case of the seeds with argon plasma treatment both of 15 min and 30 min argon plasma treatments result in almost a constant rate of pepper stem growth till the day of 21 followed by decreasing of the growth rate. In the case of the seeds with 30 min plasma treatment, the stem growth could reach almost twice compared than the stem growth of control one after 26 days of cultivation. At the end of experiments after 26 days, the root length of pepper
control was 22.3 mm, whereas the argon plasma treated ones were 44.8 mm for 15 min treatment and 55.7 mm for 30 min treatment. These experiment results showed that non thermal plasma treatment to the seeds might be a new technology as a dry process for seed growth enhancement in agricultural crops.

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