



Effect of Corona Discharge-Based Cold Plasma on Chickpea Seed Germination

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Abstract: In this study cold plasma based on corona discharge method was used. To investigate the effect of cold plasma treatment on seeds at different plasma exposure times compared to the control sample. A factorial experiment in a completely randomized design with three replications was used. Germination parameters such as germination percentage, germination rate, and root lengths were measured. The results showed a significant difference ($p < 0.01$) compared to the control in improving root length and seed vigor indices. Cold plasma treatment significantly increased germination rate and percentage compared to the control and other treatments.

Keywords: Chickpea, Cold Plasma, Germination, Seed

Introduction: Innovation with regard to food production and processing is required to meet the emerging challenges of global food security and the complexities of the modern food chain (Misra et al., 2016). Cold plasma has been introduced as a novel technology in the agricultural sector. This technology has the potential to be used for improving seed germination and plant growth. Corona discharge occurs when there are spatial inhomogeneities in the electric field, and for this purpose, asymmetric electrodes are usually used (Raizer, 2011). Extensive research has been conducted on the optimization of early seed growth and cold plasma for various seeds, however, no research has been conducted in this regard on the chickpea varieties under investigation.

Materials and methods: In this study, a vacuum pump, two asymmetric plate electrodes, and a hemispherical chamber (as shown in Figure 1) were employed to generate cold plasma using the corona discharge method. Each experimental unit consisted of 50 randomly selected seeds from each of the tested varieties. Chickpea seeds were exposed to cold plasma under vacuum for different time periods (0, 30, and 60 seconds). A control treatment without plasma exposure was also considered. To investigate the effect of cold plasma treatment on seeds at different plasma exposure times compared to the control sample, a factorial experiment in a completely randomized design with three replications was used. Following treatment of the experimental samples with cold plasma in both dry and wet exposure conditions, seed germination was evaluated in a laboratory environment and according to the International Seed Testing Association (ISTA) method. Germination parameters such as germination percentage, germination rate, and root lengths were measured. The germination percentage was calculated according to the equation 1 (Lo Porto et al., 2019):

$$G = \frac{N}{N_t} \times 100 \quad (1)$$

Where, N is the number of germinated seeds in each dish and N_t is the total of seeds in each dish. Germination rate was calculated for seeds according to equation 2 (Amnuaysin et al., 2019):

$$G_i = \sum \frac{G_t}{D_t} \quad (2)$$

Where, G_t is the number of seeds germinated per t day and D_t is number of days of germination. Seed vigor is calculated using equation 3 (Amnuaysin et al., 2019):

$$V_i = \frac{L_s \times p_g}{100} \quad (3)$$

Where, V_i is seed vigor, p_g is germination percentage, and L_s is average seedling length..

Results and Discussion: The results of the analysis of variance of the factorial experiment with the dependent variable of root length, the different factors and their interaction effects are shown in table 1. Samples exposed to cold plasma showed a significant difference ($p < 0.01$) compared to the control in improving root length and seed vigor indices. Cold plasma treatment significantly increased germination rate and percentage compared to the control and other treatments. Additionally, root and shoot lengths were enhanced in the plasma-treated samples compared to the control. The most effective treatment was the 30-second plasma exposure. As shown in figure 2, the average root length after 48 hours of sample incubation under germination conditions, with a 30-second exposure time to cold plasma, is highest in the Adel and Mansur varieties. Exposure to plasma for 30 seconds increased root length by 12.0% in Adel variety seeds and 18% in Mansur variety seeds. Since sufficient nutrient storage is essential for seed growth, the increase in average root length caused by cold plasma



may lead to increased nutrient uptake and penetration into the seeds. As previous research has shown, plasma gas little effect on the germination rate of wheat seed, but it has an effect on growth parameters such as root length compared to the control, creating up to ۱,۲ times longer (Dobrin et al., ۲۰۱۵).

Conclusion: It can be concluded that one of the effects of cold plasma on chickpea seed germination is the broader and better development of the plants root system. This can lead to increase water uptake, improves plant nutrition, and prevention of water stress. Therefore, cold plasma can be used as an effective method to improve chickpea seed germination. This technology can be potentially utilized in the future to increase the production of agricultural crops.

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Table ۱: The results of the analysis of variance of the factorial experiment

Source of Variation	df	Germination Percentage	Germination Rate	Seed Vigour	Root Length
Exposure	۲	۴,۵۲۵ ^{ns}	۲,۲۳ ^{ns}	۱۱۸,۴۱۴ ^{**}	۱۸۴۰,۰۹۷ ^{**}
Moisture	۱	۷۹,۰۵۳ ^{ns}	۰,۶۵۰ ^{ns}	۰,۵۹۴ ^{ns}	۱۴۲,۶۱۷ ^{**}
Variety	۲	۳۳,۷۹۰ ^{ns}	۲,۴۰ ^{ns}	۱۶۶۴,۶۶۸ ^{**}	۱۵۹۴,۷۲۷ ^{**}
Exposure × Moisture	۲	۱۰,۹۴۰ ^{ns}	۰,۸۰ ^{ns}	۲۲,۵۲۳ ^{**}	۱۱۹۸,۱۰۳ ^{**}
Exposure × Variety	۴	۹,۴۸۰ ^{ns}	۰,۹۰ ^{ns}	۳۹۳,۵۷۲ ^{**}	۱۸۶,۰۰۵ ^{**}
Moisture × Variety	۲	۱۹,۵۲۰ ^{ns}	۱,۲۳۰ ^{ns}	۱۳,۱۲۸ ^{**}	۲۴۹,۶۵۹ ^{**}
Exposure × Moisture × Variety	۴	۴,۷۸۰ ^{ns}	۰,۳۰ ^{ns}	۱۱۳,۶۰۳ ^{**}	۲۲,۵۳۴ ^{**}
Error	۳۶	۲۳,۳۹	۱,۲۳	۱,۱۵۴	۲,۰۰۱
CV (%)		۴,۹۳	۱۲,۳۲	۸,۵۰	۱۰,۹۰

Ns: No significant difference and **: Significant difference at the 1% level.

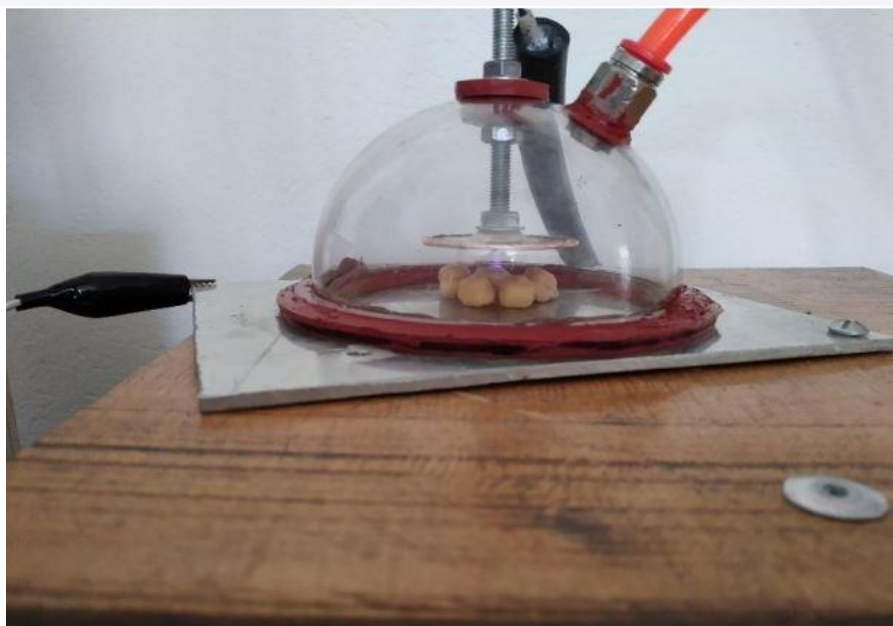


Figure 1: Cold plasma reactor using the corona discharge method

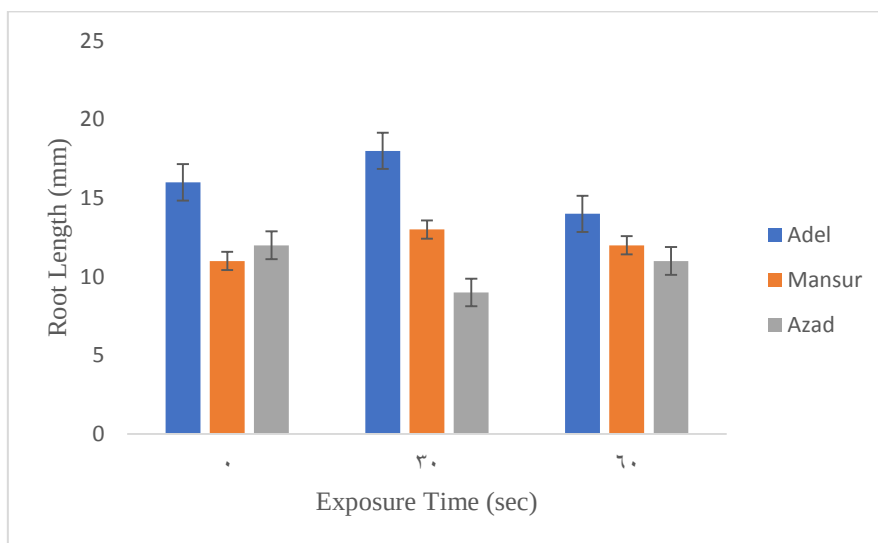


Figure 2: Correlation between average root length and plasma exposure time