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A Review : Effect of Plasma Treatment on Seed Germination of Selected Crops

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Abstract: *Plasma treatment used in different ways for expecting positive effect on seed germination of selected agricultural crops. These treatments are responsible for the more hydrophilic property of seed, which can provide more water to seed for germination and morphological changes also can be seen in plantlets. Pre - treatment showed improvement in morphological parameters such as germination of seed and its rate, root length, water uptake and yield etc.*

Key Words: *Plasma treatment, Seed germination, Agricultural crops.*

1. INTRODUCTION:

Plasma is partially ionized gases also known as a highly-energized fourth state of matter that contains ions, electrons, and reactive neutral particles (radicals, and excited atoms and molecules), and sometimes with sufficient energy to break covalent bonds and/or initiate various chemical reactions (Sookwong *et al.*, 2014)[1] · Magnetic field, ultraviolet, and other physical pathways are irradiate seeds as a traditional method to improve seed germination (Ling *et al.*,2016)[2] .

A variety of work has been carried out using plasma treatments. However, it has generally been utilised as a process tool without in-depth microscopic analysis into changes in the topography of polymers at the polymer – plasma interface. Work carried out using plasma treatment includes investigations of changes in mechanical properties and reactivity, contact angle measurements, radical analysis and changes in the sub-surface chemistry, In this paper, we describe the topographical differences caused as a result of plasma treatments (Warren *et al.*,2010)[3].

There are two main types of gas plasma treatment: low pressure and atmospheric pressure. (Warren *et al* . 2010)[3]. Gas plasma decontamination is a radically different approach and can be considered as orthogonal to 'wet' methods. For practical purposes gas plasma treatments involve exposure of the instrument surfaces to an intense flux of highly energised electrons, atoms and ions derived from gas molecules excited in a radiofrequency (RF) electrical field (Baxter *et al.*,2014)[4].

Plasma is divided into high temperature (local thermal equilibrium) and low temperature (non-local thermal equilibrium). The cold plasma contains low temperature particles like neutral molecules, atomic species and relatively high temperature electrons because of this the plasma in cold does not affect sensitive content which comes in contact (Ling *et al.*, 2014)[5]. Application of cold plasma can be by two methods: direct treatment of seed and indirect treatment with plasma activated water of seed. (Thirumdas *et al.*, 2018)[6].

In different way the effectiveness of pre-sowing seed treatment was examined by means of assessment of the *in-vitro* and *in– vivo* plants ability and seed vitality on sprouting seeds for processed and untreated samples. (FILATOVA *et al.*, 2011)[7].

Plasma treatment is mainly influenced by different treatment parameters, such as plasma properties, power levels, working gas, treatment time, as well as the type of seeds, Plasma can be effective on seeds in various ways, by modification of seed coat, by reactions with electrons, ions and radicals generated in the discharge, by UV radiation emitted from the plasma etc. (Mihai *et al.*, 2013)[8].

Cold plasma is also known as eco-agricultural technology (Jiang *et al.*, 2014)[9].Treated seeds got wet faster showed better germination (higher number of germination rates.), in a shorter period of time than untreated seeds. Plasma treatments are fast, economic and pollution-free method to improved performance and crop production (Jiafeng *et al.*, 2013)[10].

Plasma treatment of seeds can affect the early growth of plants, while too long plasma exposure may even inhibit plant growth (Sera *et al.*, 2016)[11]. Some studies showed that treatments can increase seed activity including earlier germination, higher germination rate, faster growth, enzyme activity, and the yield of plants. (Sookwong *et al.*, 2014)[1]. For instance, air plasma treatment also changes the wetting properties of seeds due to oxidation of their surface that leads to faster germination and greater yield of Wheat and oats. Wettability of seed increased by these types of technologies. (Bormashenko *et al.*, 2015)[12].

2. Literature Reviews and Observation:

Sr. No.	Name	Treatment	Observation	Author's name & Referance No.
1.	*Lupinus Angustifolius ,Galega virginiana, Melilotus albus*	Radio frequency (5.28 MHz) plasma and electromagnetic field.	Laboratory and field germination of steadfast seeds increased by 10–20 % as a result of seed coat scarification during the plasma treatment.	FILATOVA *et al.*, 2011[7]
2.	*Raphanus Sativus*	Low pressure argon plasma.	Plasma treatment of radish seeds led to an increase of root and sprout length with 11% and 10%, respectively. A more important increase of root weight (30%) was observed for the seeds exposed to plasma as compared to the untreated ones, while the sprout weight was enhanced with almost 15%. The root-to-shoot mass ratio was also 15% higher for the treated seeds. It was found that the roots and sprouts of plasma treated seeds were longer and heavier than those of control seeds. Better results were observed for longer treatment time which is 20 min.	Mihai *et al.*, 2013[8]
3.	*Arachis hypogea L.*	helium plasma discharge.	Germination potential, germination rate, and dry weights of seedlings were markedly increased after cold plasma treatment. Under field conditions, leaf area, leaf thickness, and dry weight at the fruiting stage; plant height, stem diameter and root dry weight at the mature stage; and yield were improved by cold plasma treatment. 120 W treatment produced the best effect.	Ling *et al.*, 2016[2]
4.	*Oryza sativa L.*	Air plasma.	Seed germination has often been correlated with water imbibition. Increasing water imbibition results to an increase in seed germination. Plasma treatment of various polymer surfaces results to a decrease in surface roughness which in turn makes them more hydrophilic. The effect of plasma exposure shows a reduction of trichomes on the surface of the seed.	Penado *et al.*, 2017[13]
5.	*Triticum aestivum L. Cv. Eva*	Cold plasma.	Germination potential and germination rate of control were 84.0% and 83.3%. Treatment of 80 W could increase germination potential (6.0%) and germination rate (6.7%) of wheat seeds. There's no differences compared to the control.	JIANG *et al.*, 2014[9]

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6.	*Chenopodium Album*	The plasma discharge in a fog-like form (Ar/O2, Ar/N 2 generated.	The seeds under plasma irradiation of 12~48 minutes started to germinate before the first data monitoring. The seeds with 6 minutes of plasma irradiation and the seeds in the control conditions started to germinate before the second data monitoring. Germination rate for the untreated seeds was 15% while it increased approximately three times (max 55%) for seeds treated by plasma from 12 minutes to 48 minutes.	Sera *et al.*, 2008[14]
7.	*Lensculinaris and Phaseolus vulgaris*	The plasma treatment of polymer.	The speed of germination and yield of seeds can be modified by preliminary plasma treatment.	Bormashenko *et al.*, 2012 [12]
8.	*Cannabis sativa L.*	Low-pressure and low-temperature microwave apparatus generating plasma.	Treated samples had a small number of germinated seeds than control samples. The length of seedlings of all cultivars pre-socked by GA were usually bigger than control samples. The length and weight of seedlings were 153 % and 127% respectively (after 300 s plasma explosure).	Sera *et al.*, 2016[11]
9.	*Glycine max (L.) Merr*	Pre-treatment of cold plasma with 0, 60, 80, 100 and 120 W for 15 s.	No treatment had a significant effect on the germination potential or rate. The 80 W cold plasma treatment produced the highest incentive effect. Germination and vigour indices significantly increased by 14.66% and 63.33%, respectively.	Ling *et al.*, 2014[5]
10.	*Solanum lycopersicum L.*	Cold plasma	Germination potential and germination rate of the controls were 67% and 80% respectively, whereas cold plasma treatment increased the germination potential of tomato seeds by 8%, and significantly increased the germination rate by 11%, compared to the control.	Jiang *et al.*, 2014[9]
11.	*Chenopodium quinoa, Willd*	Atmospheric and low pressure	In comparison, with untreated seeds those treated with RF plasmas for 10 s observed improvement in germination, reaching up to 100% after five days. Plasma treatment times of 60 s produced a germination success rate up to 80% after 8 or more days.	Gómez-Ramírez *et al.*, 2017[19]
12.	*Coffea arabica var.*	Atmospheric plasma and helium gas	The germination rate of coffee seeds decreased after short exposure to plasma as compared to non-treated seeds. When the seeds were exposed to plasma for 120s , germination was advanced but germination rate was the same as that of the control. Plasma treatment have increased water uptake of the seeds by 10-12% compared to control treatment.	Tounekti *et al.*, 2018[20]
13.	*Citrullus lanatus*	Cold atmospheric plasma jet	The germination percentage increased by 72%, 93.5%, 75%, 87% and 85% at 2, 4, 6, 8 and 10 min operation time of cold plasma treatment respectively.	Lotfy *et al.*, 2017[21]

14	*Vigna radiata (Linn.) Wilczek.)*	Atmospheric-pressure, N2, He, air and O2 microplasma.	Germination percentage of Mung bean treated with the air plasma reached 80%, significantly higher than that reached by seeds treated with O2 micro plasma (15%) and He and N2 plasmas (below 10%). After incubation for 24 h, the germination percentage of air plasma treated samples reached approximately 95%, whereas the corresponding value for O2 plasma treated seeds ascended to 72%. Seeds treated by He and N2 plasma had the lowest germination rate of 30%, almost the same as that for control samples.	Zhou *et al.*, 2016[22]
15	*Gossypium sp.*	Atmospheric plasma	Water uptake measurements of seeds confirm that plasma treatment can improve the imbibition of water in seeds.	Wang *et al.*, 2017[23]
16	*Ocimum basilicum* L.	Radiofrequency room temperature plasma method	T3 and T4 treatments significantly increased the germination percent by 16.3% and 20.5%, seedling vigor index I by 32.6% and 48.1% and seedling vigor index II by 4.7% and 66.6% respectively, against control.	Singh *et al.*, 2019[16]
17	*Spinacia oleracea*	magnetized arc plasma	The germination vigour increased by 217.6% and the germination rate by 137.2% for a treatment intensity of 2.0A repeated three times.	Shao *et al.*, 2013[17]
18	*Cicer aeritinum*	Cold atmospheric plasma	The total percentage of seed germination increased up to 89.2% when exposure to 1 minute in Cold atmospheric plasma. (89.2 %).	Mitra *et al.*, 2013[18]

3. RESULT & DISCUSSION:

It is shown that plasma and radio-wave treatments result in the increase of the laboratory and field germination of seeds as well as their vitality, in the reduction of seed contamination level with fungal infections in *Lupinus angustifolius* and *Galega virginiana*. (Filatova *et al.*, 2011)[7]. Non-thermal plasma treatment of seeds may have a positive effect on plant early growth just like in radish.(Mihai *et al.*, 2014)[8].In cold plasma treatment, A. *Hypogea* showed improvement in seedling growth. The treatment power was 60 W (T1), 80 W (T2), 100 W (T3), 120 W (T4), or 140 W (T5).The shoot dry weight for the T4 treatment was 46.62 mg, which was 11% higher than control. The T2, T3 and T4 treatments increased the root dry weight by 4%, 5% and 9%, respectively, compared to control. (Ling *et al.*,2010)[1] .

Seed germination of rice has often been correlated with water imbibition. Increasing water imbibition results to an increase in seed germination (Penado *et al.*,2017)[13]. The seed germination that was triggered by microwave plasma treatment under light-night conditions at laboratory temperature. The number of germinating seeds after plasma treatment increased, germination time was reduced, and the growth rate of seedlings increased. All results of experiments confirmed that plasma treatment is a useful process for overcoming dormancy of C*henopodium album*. This physical treatment may be functional for other plant species with analogous physiological seed dormancy. (Boˇzena ˇSER´ A *et al.*, 2008)[14].

In Lentils (*Lens culinary*) and beans (*Phaseolus vulgaris*) it should be stressed that this 15 s plasma treatment did not change the topography of the seed surface (Bormashenko *et al.*,2012)[12]. In soybean plasma treatment could promote the accumulation of soluble sugar and protein by increasing the activities of enzymes, such as a- amylase and proteases which found that that were related to their metabolism (Li ling *et al.*, 2014)[15] . In *Ocimum basilicum* L. cold plasma treatment T4 (150 w RF power) shows better outcome and had the highest stimulatory effect on germination and vigour among all the studied doses of treatments (Singh *et al.*, 2019)[16].

In spinach the germination vigour increased by 217.6% and the germination rate by 137.2% for a treatment intensity of 2.0 A repeated three times by treatment of magnetized arc plasma (Shao *et al.*, 2013)[17]. The roughness of this seed coat of *Cicer aeritinum* cotyledon was altered significantly, only in case of longer cold plasma treatment times from 5 min. (Mitra *et al.*,2013)[18].

4. CONCLUSION:

Plasma treatments are different from each other and showing different results in given seeds at different time. Continues treatments are showing different results than discontinues treatment. Various intensity of treatment showed unique rate of seed germination and different morphological variable. These confirms that the plasma treatments surely lead us with positive results in germination of seed and other morphological parameters also. These treatments are surely effective on the agricultural basis for the getting abundant production of the taken economic field crops.

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