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Abbreviations

HP: Hybrid-Plasma; NTP: Non-Thermal Plasma

Research Article

Hybrid-Plasma, a Newly Formed Environment for Growing Plants without Soil or Water

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Abstract

Introduction: We have discovered a new form of Non-Thermal Plasma (NTP) that is produced without added external energy. This Hybrid-Plasma (HP) is a mixture of water and gas whose formation is dependent on a purely passive process.

Methods: In the present study we exposed developing Mung bean seedlings (n=10) to HP in an enclosed compartment without water or soil for 7 days. An equal number of age paired seedlings were grown hydroponically for comparison. Seedlings were then removed from the HP and grown hydroponically for another week.

Results: Over the initial test period, the seedlings grown in the HP showed significantly diminished growth of stem length and leaves were under-developed compared to the hydroponically grown controls ($p<0.05$). When the seedlings in HP were placed in the hydroponic environment for another week, leaf growth resumed but was markedly diminished compared to its age paired partner.

Conclusion: Seedlings exposed to HP for a week exhibited growth, albeit diminished, compared to its age paired partner. These findings suggest hybrid plasma has anti-aging properties.

Introduction

In a recent report we described a production method for Non-Thermal Plasma (NTP) without external energy [1]. We placed a sealed jar containing room air under a large volume of distilled water. Free water molecules (2.7Å) separated from bulk water along an osmotic concentration gradient through the pores in the glass jar (8-12Å). We hypothesized that once separated from bulk water highly kinetic free water molecules reacted and stripped electrons from the neutral water atoms. The resulting mixture of positive and negative ions constitutes a low-level ionization reaction, i.e., a non-thermal plasma, NTP. Based on sustained levels of humidity (99%) and ion values greater than 1000×10^3 cm^3, we designated this new form of NTP, Hybrid-Plasma (HP), a mixture of water and gas. In the present study plants were grown in the HP environment without soil or water for one week and compared to age paired plants grown hydroponically. A non-thermal plasma is an ionized reaction occurring at or near room temperature, consisting of positive and negative ions, free electrons and neutral atoms.

Methods

The hybrid-plasma generator

In the present study, we used a second method for producing hybrid-plasma than previously reported [2]. A large plastic storage container served as the source for developing the HP environment from a large pool of water (800cc) confined in an enclosed plastic container (Figure 1).

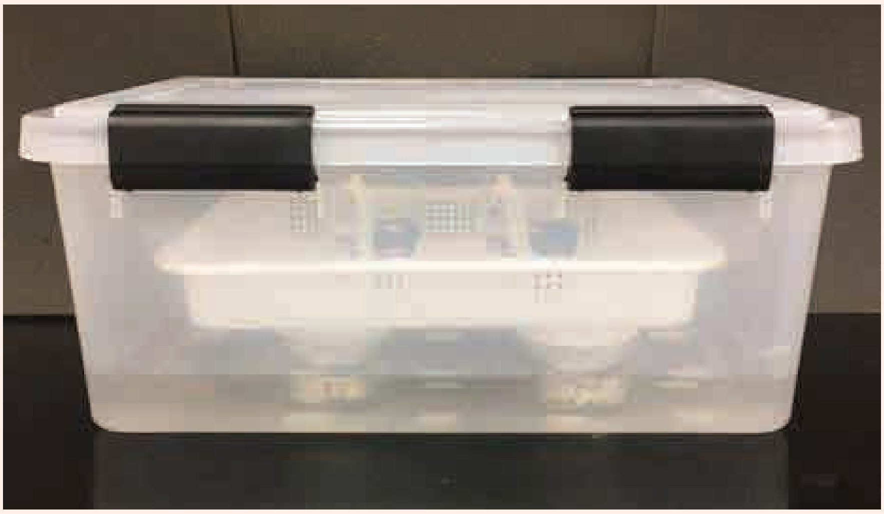

Figure 1: Eight hundred mL of distilled water at the bottom of a large plastic container was first instrumented with 350mL beaker holding a mini-ion counter and hygrometer sitting on a platform above the water level. The container was sealed for 24 hours.

A rectangular plastic insert lined with perforations standing on weighted jars, served as a platform above the water level. Ion counters and hygrometers were placed inside 500mL beakers that collected and accumulated hybrid-plasma. The plastic container was sealed by snap covers. Over 24 hours, as free molecules diffused into the air space from the water inside the sealed container, their kinetic interaction as described previously [1], resulted in HP accumulation. The self-sustained ionization reaction was registered by a mini-ion counter and hygrometer in the beakers. Within 24-48 hours, the ionization level was well over 1000x10^3 ion counts/cm^3 and a humidity level of 99%. A similar enclosed plastic container was also tested after the same time period and registered 2-300 ion counts/ cm^3 and a relative humidity of 40%. Mung bean plants were germinated and sprouted in 200mL beakers filled with distilled water (n=12). A stainless-steel strainer was placed on each beaker so that a small amount of water was showing in the strainer. Ten Mung bean seeds were put into the water well in each strainer. Each beaker was placed in a drawer which was closed to keep the beans in the dark for 48 hours. When returned to the light, the husks that were shed from the seeds were discarded allowing the sprouted seedlings to start growing as small plants. Another set of seedlings were also grown hydroponically under similar conditions and served as controls. The experimental set of seedlings, once germinated and growing, were removed from the water, the roots and base of the strainer lightly blotted to remove excess water. The strainer with seedlings was placed in one of beakers containing hybrid plasma as shown by the positive readings of the ion counter and hygrometer taken from the sealed compartment of the large plastic container. The waterless plant was placed under an inverted plastic cylinder (Figure 2). The condition of all the plants was monitored daily. At the end of a week, plants were removed from their strainers and comparable measurements were made of stem length and leaf area (length X width).

Ancillary experiment

Another set of age-paired plants, treated as above without water, were allowed to grow for one week. At the end of a week, the plant growing in hybrid-plasma was removed and placed in a beaker with water matching the hydroponic state of its age paired partner. The two plants were observed daily for the next 7 days.

Statistical analysis

The measurements of stem length and leaf area were compared between plants grown hydroponically and those grown in a sealed waterless environment with sustained values of 99% humidity and > than 1 million ion counts/cm^3 using a non-paired T-test. A p-value of < 0.05 was considered significant.

Results

Figure 2 illustrates that the plant that grew hydroponically developed as would be expected. The plant previously placed in a jar exposed to HP for 24 hours and then transferred and confined in the sealed cylinder also had grown but the leaves were markedly under developed compared to its aged paired partner. Plants placed in the ambient environment had completely wilted within hours (not shown).

Figure 2: Paired age plants (Left: hydroponic/Right; in hybrid-plasma for one week).

Table 1: A statistical comparison of Stem Length and Leaf Area of Plants Grown in Water (control) vs. Plasma. There was a significant decrease in the stem length and leaf area of the seedlings grown in HP compared to those of the plants grown hydroponically, p<0.04, p<0.0003, respectively.

	Control		Plasma	
Exp. #	Stem-Length	Leaf-Area	Stem-Length	Leaf-Area
1	18	4.5	13	0.8
2	18	3.4	13	0.8
3	14	5.3	15	0.8
4	13	5.2	9	0.2
5	21	5.4	13	0.9
6	14	5.7	17	0.5
7	15	2.5	10	0.5
8	17	1.6	14	0.9
9	20	3.1	15	0.9
10	17	3..8	18	0.8
Average	17	4.1	14	0.7
SD	3	1.5	3	0.2
p-value			0.04	0.0003

Discussion

Major findings

Paired Mung bean seedlings of the same age were grown hydroponically before being separated so that one was removed from water and placed in a beaker containing HP. The beaker was placed under an inverted acrylic container which was instrumented with a hygrometer and min-ion counter. After 7 days both seedlings showed growth but the one grown in the HP was significantly undersized in stem length and leaf area, p<0.05. Humidity levels were consistently over 90% an ion counts over 1000x10^3 ions /cm^3. After one week in the waterless environment the undersized seedlings were returned to the hydroponic environment. After seven days of continued growth, the one grown in HP was still undersized compared to its same aged partner.

Background

In our initial studies, we documented the development of a new form of non-thermal plasma which was formed by the osmotic movement of free water molecules [1] that separated from bulk water and became by its inherent kinetic energy a self-sustaining reaction or non-thermal plasma. Previous methods for non-thermal plasma production had relied on the application of external energy, usually in the form of electrical discharges applied to a gas [3]. An important difference between the two methods is that the passive form of plasma can be accumulated and stored, whereas the previous method produces a short-lived plasma (seconds). We defined this new form of NTP as a plasma consisting of a mixture of water and gas, Hybrid-Plasma (HP). Evidence that water was present was indicated by humidity level at or near 99%, well above ambient humidity. Evidence of the presence of a gas was indicated by the ionization levels throughout the enclosed container which correspond with ion counts well above 1000x10^3 ions/cm^3.

Anti-aging properties of hybrid-plasma

The present study provides observations which suggest that HP can sustain seedling growth, albeit in a diminished form of both stem length and leaf area, for prolonged periods, in this case 7 days, without liquid rather than sequestered in HP. On the other hand, same age partners, grown hydroponically showed normal growth of stems and leaves. We concluded that the observations made about the seedling growth during exposure to HP constituted an anti-aging effect. The idea that there is a negative relationship between the Resting Metabolic Rate (RMR) and lifespan is at least 100 years old and probably originated with Rubner [4] who observed in 1908 that larger, longer lived animals had lower metabolic rates and in particular that the product of their metabolism (per gram) and lifespan was essentially constant. Others have proposed that organisms that grow fast due to a higher metabolic rate have a shorter lifespan than those who have low metabolic rates, citing the shorter life span of mice compared to whales [5]. This theory has not been without its detractors [6]. We hypothesize that the leaf, being the source of the plant's metabolism, had a reduced size which slowed the metabolic engine. Reduction of metabolism is the basis of the delayed growth and potentially longer lifespan.

Limitations

That the finding of a delayed growth pattern by the seedling exposed to HP is an indication of an anti-aging property needs to be judged by the actual comparison of the life time of the two pared seedlings. It could be argued the results are not indicative of anti-aging but a non-specific injury induced by the HP. The plants grown in the ambient environment, without water wilted in 24 hours, a definitive form of damage to the plant. On the other hand, the plant in HP continued to grow, although in a mitigated form, for one week without water and resumed normal growth when placed in water for another week without signs of damage. Future studies are planned to expose animal organisms with finite, short lifespans to the HP, C elegans [7] in order to test the putative anti-aging properties of our newly described NTP.

Conclusions

We compared the growth of Mung bean seedlings grown hydroponically vs. those grown in a new form of non-thermal plasma, a hybrid of water and gas (Hybrid-Plasma) for 7 days. The latter showed diminished growth of stems and leaf area over the test period. When the seedling in HP was placed in the hydroponic environment for another week, growth resumed but was markedly diminished compared to its age paired partner indicative of an anti-aging effect of HP.

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