22G12

Effect of atmospheric pressure torch plasma irradiation on plant growth
大気圧トーチプラズマ照射による植物成長への効果

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Growth stimulation characteristics of plants seeds are investigated by an atmospheric discharge plasma. Atmospheric pressure plasma torch is consisted of alumina ceramics tube and the steel mesh electrodes wound inside and outside of the tube. The growth stimulation was observed in the length of a stem and a root after the plasma irradiation. The stem length increases approximately 2.8 times at the cultivation time of 24 h. And the growth stimulation effect is found to be maintained for 40 h, after sowing seeds. The mechanism of the growth stimulation would be the redox reaction inside plant cells induced by oxygen radicals.

1. Introduction

Recently, the growth stimulation of living bodies such as cells, microorganisms, and plants has been studied utilizing electrical pulses [1] and discharge plasmas [2-5]. When seeds of plants such as radish sprout are irradiated with discharge plasma, the growth speed of the sprout is observed to be accelerated throughout its lifetime. Stress responses that have been maintained for long periods, i.e., on the order of a lifetime, are related to the genome. The above stresses would modify the structures of the genome such as DNA, RNA, and transcription factors. Transcription factors are types of protein that transcribe genome information from DNA to RNA; they are activated by external stresses like heat and impact.

One of the promising candidates of the growth acceleration mechanism is associated with heat shock factors (HSFs). HSFs generate heat shock proteins when a living body receives external stresses, and accelerate cell growth for survival against the stresses. The control of plant growth by external stresses is possible by the modification of the structures of HSFs. The switch of HSFs would be the cystein-cystine redox reaction of Thiol compounds such as thioredoxin and Gultathione in HSFs forming disulfide bonds. Therefore, thiol compounds are major substances that cope with external stresses to living bodies. In this study, radicals were used to characterize and control the redox treatment of thiol compounds. Also, the quantity of total thiol, which mainly comprises thioredoxin and Gultathione in plants, is measured in order to confirm redox reactions using radicals in oxygen plasma. The correlation between the thiol quantity and the stimulation of plant growth clarifies the mechanism of the growth stimulation phenomenon induced by plasma irradiation.

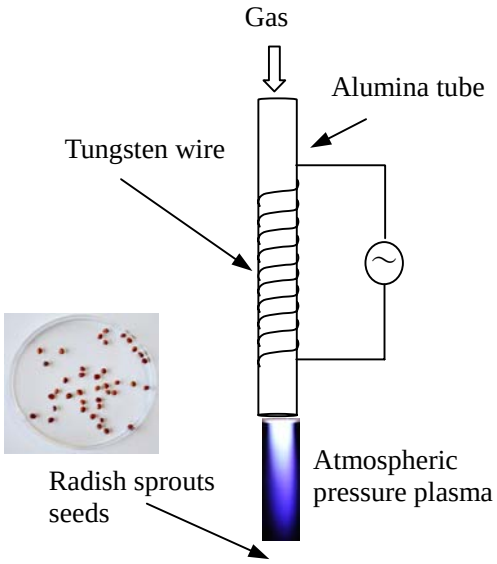

Fig.1: Atmospheric pressure torch plasma apparatus

2. Experimental Procedure

Fig.1 shows the schematic diagram of the atmospheric pressure plasma torch apparatus. Atmospheric pressure plasma torch is consisted of alumina ceramics tube and the steel mesh electrodes wound inside and outside of the tube, with the dimension of 130 mm in length and 3 mm in a diameter. When AC high voltage (8 kHz) is applied to the electrode gap, the barrier discharge plasma is produced inside the alumina ceramics tube. The barrier discharge plasma is blown outside with the gas flow in ceramics tube. The gas served in this experiment is pure oxygen and nitrogen.

Radish sprouts seeds locate at 1 cm from the torch edge. After the irradiation of the plasma for 10 min or 20 min or 30 min or 60 min, the seeds are sown to the cultivation pot after the plasma irradiation. The length of the radish sprouts is recorded every 24 hours.

3. Results And Discussion

3.1 *Enhancement of Plant Growth Speed by Plasma Irradiation*

The growth stimulation was observed in the length of a stem and a root after the plasma irradiation. Fig.2 relation between cultivation period and sprout length The stem length increases approximately 2.8 times at the cultivation time of 24 h. And the growth stimulation effect is found to be maintained for 40 h, after sowing seeds. Therefore, the mechanism of the growth stimulation would be the redox reaction inside plant cells induced by oxygen radicals.

3.2 *Redox Reaction of Thiol Compound and Growth Enhancement Mechanism*

Fig.3 illustrates the relation between the thiol quantity of plant seeds and the oxygen plasma irradiation period. The oxygen plasma irradiation decreases the thiol quantity with the treatment period. This result indicates that the reduction type thiol is oxidized by oxygen radical. Increase of the reduction type thiol in cells tends to activate transcription factors and related growth-promoting factor activated by reduction type thiol are one of candidates of plants growth mechanism.

4. Conclusion

The growth stimulations in plant length are studied using radicals produced in atmospheric plasmas. The thiol quantity of radish sprouts, which is related to the redox reaction between cystein, cystine and the growth factors, would be modified by plasma irradiation. Therefore, reactive plasma would be served as a good tool for the control of redox reactions in plants and plant growth.

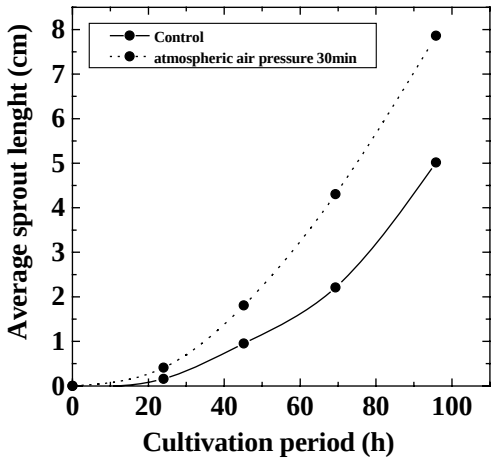

Fig.2**:** Relation between cultivation period and sprout length

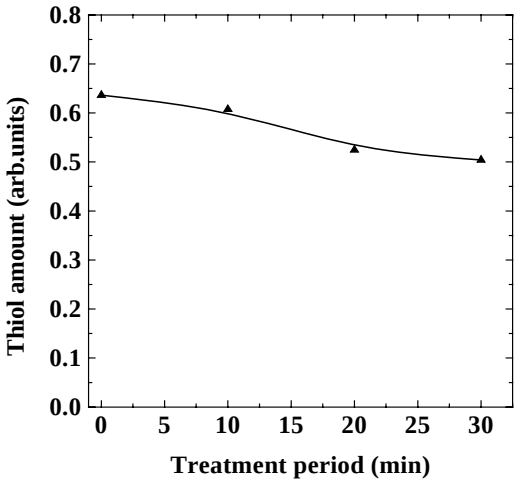

Fig.3 Relation between thiol quantity of plant seeds and O_2 plasma irradiation period.

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