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The Effect of High Voltage Interchange Electric Field Processing in the Water Culture of *Lactuca sativa* L.

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Abstract — In recent years, the interest in functional waters has been increasing in various fields. The influence of functional waters was examined in the water culture of *Lactuca sativa* L. with high voltage interchange electric field processed water. As a result, the root lengths of the ward treated for five hours were about 11 percent longer than the length of the non-treated ward. The total fresh weight of the ward treated for three hours was about 25 percent heavier than the total fresh weight of the non-treated ward. The total dry weight of the ward treated for two hours was about 36 percent heavier than the total dry weight of the non-treated ward. The near infrared absorption spectra shifted to the long wavelength side at the peak region of 1450nm with the treatment of high voltage interchange electric field processing. The structure of processed water was at a low temperature state because the peak shifted to the short wavelength side with increasing water temperatures. As a result, it is suggested that the growth speed of the *Lactuca sativa* L. was increased by changing the water structure through high voltage interchange electric field processing.

1. Introduction

In recent years, a type of treated water called "functional water" has attracted interest from medical and agricultural fields. Functional waters are produced by energy treatments using electrolysis, high voltage interchange electric fields, magnetic fields and ultra sounds, and the addition of minerals. The effects of functional water have been investigated from various points of view: (1) Disinfection of microbes by electrolyzed water [1)-3)]; (2) Rust proofing of pipelines by magnetic treatment[4)-5)]; (3) Effects of various kinds of treated water on plant growth[6)-13)]. These processing methods each have an important characteristic in that they only require a small amount of treatment to attain a big effect. Therefore, it is very important that the water treatment techniques are used generally through elucidation of the mechanism.

The purpose of this study is to accumulate basic data for elucidation of the mechanism that

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occurs with various functionalities of functional water and to confirm any effects. In this study, high voltage interchange electric field processing was adopted because it was not necessary to think about the influence on water structure by impurities. The evaluation of this water treatment method was done with water cultivation of *Lactuca Sativa* L. because it is reported that the influence of functional water on plant growth is significant[6)-13)].

2. Experimental

2.1 High Voltage Interchange Electric Field Processing

High voltage interchange electric field processing is made possible with a device manufactured by Nihon Riko Medical Corporation called "Dr.Tron" (YK-9000) (Fig. 1). This device produces 9000V of alternating current with 100V of power. The object to be processed is treated with a high voltage interchange electric field in a container, such as a tank, on an electrode board. This device is also characterized by its small consumption of electricity (max 15W).

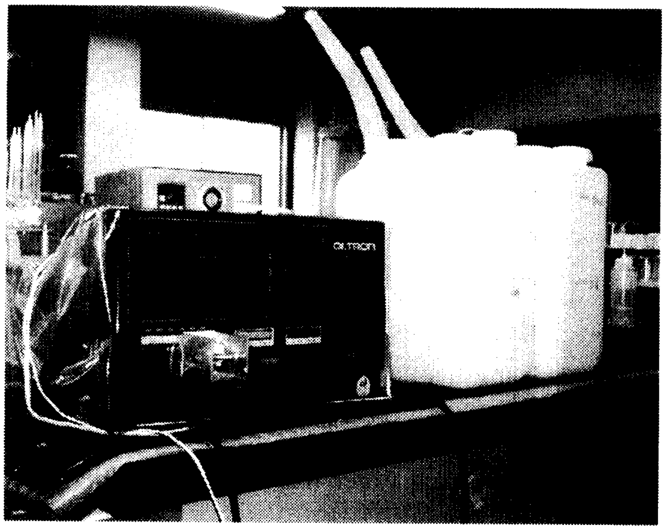

Fig. 1 Photograph of high voltage interchange electric field processing device.

2.2 Cultivation Device

The seedling growth device and the water cultivation device are shown in Fig. 2 and Fig. 3 respectively. The seedling growth device had two mixed lighting systems. The lighting system consisted of four 20W fluorescent Plantlux lamps (FL20SS•BRN/18A: Toshiba Lighting & Technology Co.) and the same number of white fluorescent lamps (FL20SS•N/18: Matsushita Electric Industrial Co., Ltd.).

The water cultivation device consisted of a rotary lighting system, eight cultivation beds and an air circulation system. The rotary

Fig. 2 Photograph of seedling growth device with aerator.

lighting system had four 360W improved color rendering high pressure sodium lamps (NH360FDL: Iwasaki Electric Co., Ltd.) and an aluminum tower. The quantity of light irradiated on the eight cultivation beds was able to be kept at a constant amount by rotating the lighting system. The cultivation bed had a board of foam polystyrene in a plastic container (D60*W45*H15cm) and an electromagnetic pump (SL-06: Elepon E.C.A.P. Co.) to circulate the water culture solution. The flow rate of water culture solution was kept at 8*l*/min by using the electromagnetic pump in order to attain the most suitable flow speed of 3cm/s [14] for cultivation of *Lactuca sativa* L.. The air circulation system had four small fan motors (3610PS-10T-B30: Minebea Co., Ltd.) and one large fan motor (5915PC-10T-B30: Minebea Co., Ltd.). A flow of air was blown towards the *Lactuca sativa* L. by the small fan motors. Distributions of room temperature and humidity were made even by the large fan motor.

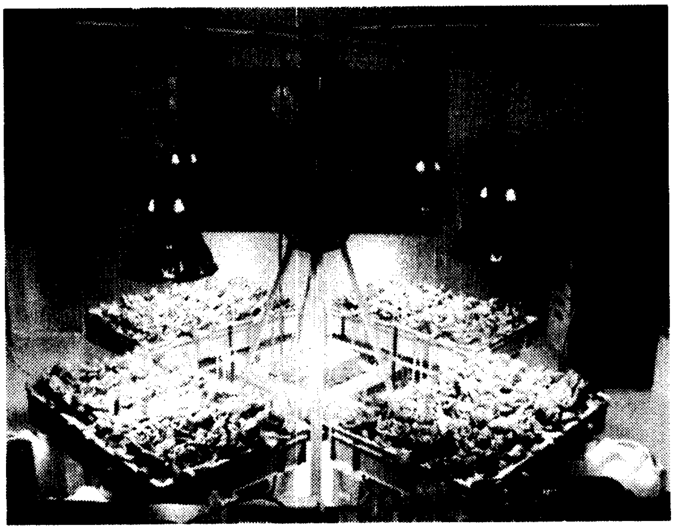

Fig. 3 Photograph of water cultivation device with rotary lighting system.

2.3 Experimental Method

The germination was performed in a 22.5°C incubator for 48 hours. Seedlings were grown until their weight reached approximately 2g over 18 days with the seedling growth device (Fig. 2). During the growth period, the water culture solution in the device was changed with fresh standard water culture solution (Otsuka Chemical Co., Ltd. MK-1:MK-2=1:1, EC=250mS/m) every two days. The seedlings were then moved and cultivated in the cultivation device (Fig. 3) with the high voltage interchange electric field processed water culture solution for 10 days. The treatment conditions with the high voltage interchange electric field processed water culture solution and the cultivation conditions after permanent planting are shown in Table 1 and Table 2 respectively. One half of the water solution in the cultivation device was replaced every two days in order to keep constant the concentration of the various ingredients in

Table 1 Treatment conditions for high voltage interchange electric field processing of water culture solution in cultivation device.

Conditions	Processing time (h)	Electric conductivity (mS/m)
①	0	
②	0.25	
③	0.5	
④	1	250
⑤	2	
⑥	3	
⑦	4	
⑧	5	

solution. In addition, the lighting system was rotated 90 degrees every four hours during the cultivation period in order to keep constant the irradiation of all of the cultivation trays. After the cultivation, the total fresh weight, total dry weight, and root lengths of the *Lactuca sativa* L. were measured.

Table 2 Cultivation conditions after permanent planting in the cultivation device.

pH	6.8± 0.15	
Electric conductivity	240 ±15	mS/m
Water temperature	22.5± 2	°C
Room temperature	24.0± 2	°C
Humidity	65 ± 5	%
Illumination	27000～32000	lux

Near infrared spectra of the treated water were obtained on a spectrophotometer (UV/VIS/NIR spectrophotometer V-570 with Peltier type thermostated quick flow sampler CQF-483S: Jasco Co., Ltd.). The temperature of each sample was kept constant at 25°C with precision of 0.01°C during the measurement.

3. Results and Discussion

The total fresh weight, total dry weight, and root lengths of the *Lactuca sativa* L. were affected by the high voltage interchange electric field processing of the water culture solution. The root lengths of the ward treated for five hours were about 11 percent longer than the length of the non-treated ward (Fig. 4). The total fresh weight of the ward treated for three hours was about 25 percent heavier than the total fresh weight of the non-treated ward (Fig. 5). The total dry weight of the ward treated for two hours was about 36 percent heavier than the total dry weight of the non-treated ward (Fig. 6).

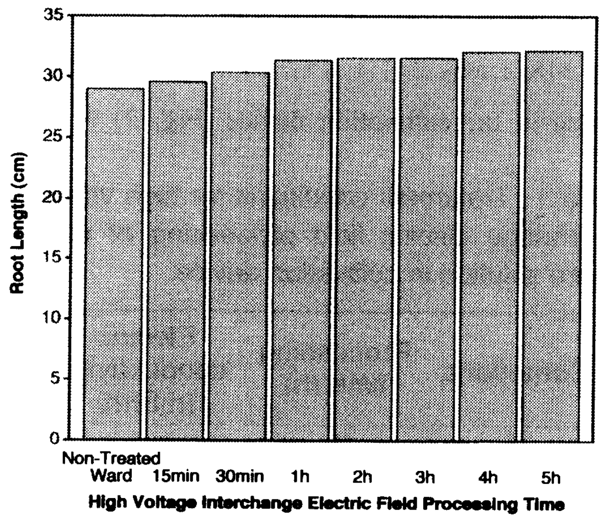

Fig. 4 Relation between high voltage interchange electric field processing time and root length (average of 108 roots).

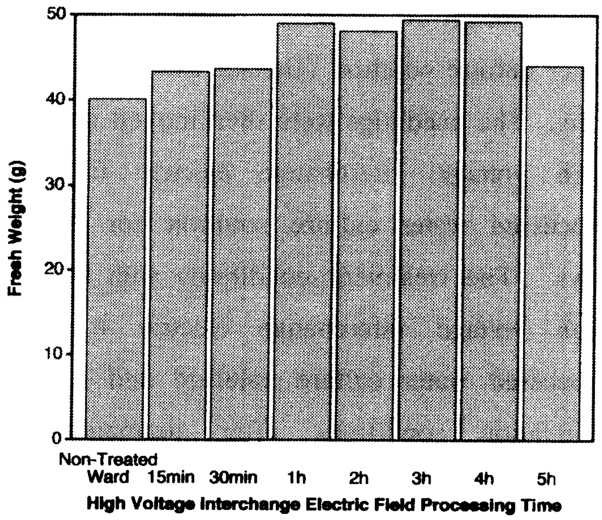

Fig. 5 Relation between high voltage interchange electric field processing time and total fresh weight of leaves (average of 108 heads).

The near infrared absorption spectra (Fig. 7) show that the peak region of 1450nm shifts to the long wavelength side with the treatment of high voltage interchange electric field processing. On the other hand, the peak shifts to the short wavelength side with increased water temperatures (Fig. 8). Therefore, the cluster structure of processed water was at a state of low temperature. As a result, it is suggested that the cluster structure of water was changed by high voltage interchange electric field processing.

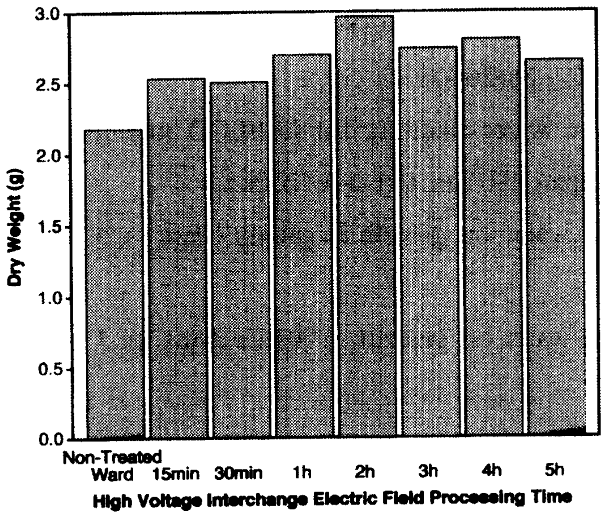

Fig. 6 Relation between high voltage interchange electric field processing time and total dry weight of leaves (average of 108 heads).

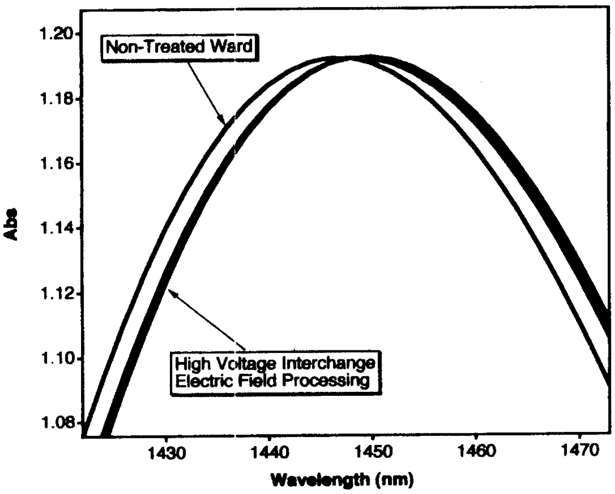

Fig. 7 Near infrared absorption spectrum of high voltage interchange electric field processed water.

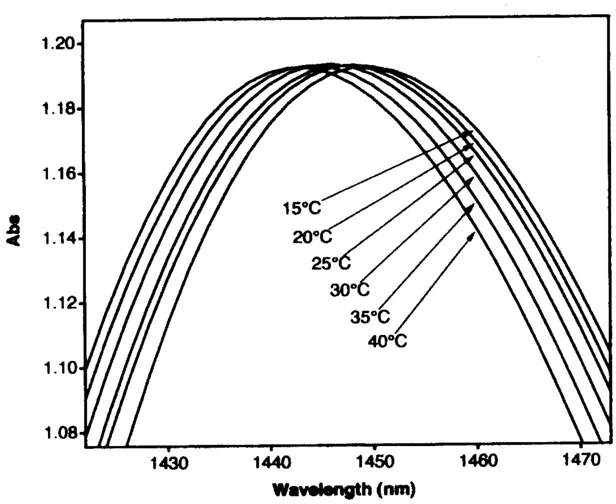

Fig. 8 Near infrared absorption spectrum of water within temperature range of 15-40 °C.

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