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OZONE-MIST SPRAY STERILIZATION FOR PEST CONTROL IN AGRICULTURAL MANAGEMENT

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We have developed a portable ozone-mist sterilization system to exterminate pests (harmful insects) in agricultural field and the greenhouse. The system is composed of ozone generator, water spray ,and oxygen small container. The ozone generator can supply high dense ozone using the surface dielectric barrier discharge. Ozone-mist is produced using a developed nozzle. We studied the effects of ozone-mist spray sterilization on insects and agricultural plants. The sterilization conditions are estimated by monitoring the behavior of aphids and observing the damage of the plants. It was shown that aphids were exterminated in 30 sec without noticeable damages of the plant leaves.

1. Introduction

Ozone sterilization in agriculture is one of promising technologies to secure safety of food processing. Environmentally friendly alternatives to agricultural chemicals for plant fumigation have been required. The recent interest in organic products has been heightened by consumers' increased expectations regarding their food and the environment. Organic agricultural methods are internationally regulated and legally enforced by many nations. Biological pest control in organic farming includes herbicides, insecticides and fungicides.

Ozone (O_3) is the strongest commercially available disinfectant and also is very effective at destroying bacteria, viruses and odors. It has a very short half-life in air, water and soil, and decomposes in simple diatomic oxygen or forms oxide matters.

We have studied the application of gaseous ozone to soil sterilization and the biological effect of gas phase ozone on the DNA genome contained in bacteria and viruses [1-10]. We have developed the gaseous ozone sterilization system for agricultural soil which ensures a secure agricultural production. The reaction of the agricultural matter including air, water ,soil and plants with ozone causes complicated change in physical, chemical and biological properties.

Here, we proposed a portable ozone-mist sterilization system to exterminate pests (harmful insects) in agricultural field and the greenhouse. The system is composed of ozone generator ,water spray ,and oxygen small container. The ozone generator can supply high dense ozone of maximum concentration of 86 g/m^3 at a flow rate of 1 liter/min using the surface dielectric barrier discharge. Ozone-mist is produced using a developed nozzle. We studied the effects of ozone-mist spray sterilization on insects and agricultural plants. Most of pathogenic viruses like mosaic viruses are transmitted and spread by aphids and also by mechanical means.
The ozone-mist treatment conditions for aphid sterilization system were studied for practical use in agriculture.

3. Results and Discussion

Figure 3 is a typical picture after ozone-mist treatment (30sec) for the red aphid (Uroleucon nigrotuberculatum). The conditions were ozone concentration of 68g/m^3 with a oxygen flow rate of 2 liter/min and water flow rate of 300ml/min. We found 98% of the aphids died. The treatment was performed at the distance (d) between the ozone ejection nozzle and the sample of 20mm. The survival rate(=survival account /total account) rapidly decreased with the distance(d).

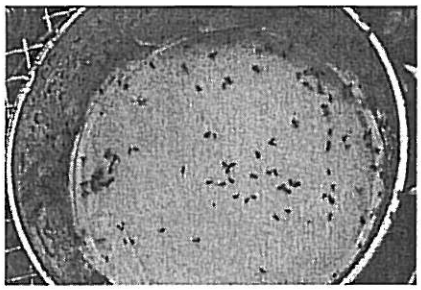

Fig.3 Photo of red aphids treated by ozone-mist spraying for 30 sec.

Figure 4 and 5 show the survival rate as a function of the treatment time at the distance of 50mm. The rate was about 8% at the short treatment time till 60 sec and then decreased rapidly with increasing time.

When ozone reacts with water-mist, highly unstable and rapid decomposition occurs.

The elementary reactions follow:

$OH^- + O_3 \rightarrow {}^*HO_2 + {}^*O_2^-$ (1)

${}^*HO_2 = H^+ + {}^*O_2^-$ (2)

${}^*O_2^- + O_3 \rightarrow O_2 + {}^*O_3^-$ (3)

${}^*O_3^- + H^+ \rightarrow HO_3$ (4)

$HO_3 \rightarrow O_2 + {}^*OH\cdot$ (5)

$O_3 + {}^*OH \rightarrow {}^*HO_2 + O_2$ (6)

Initial formation of the superoxide ion radical ($^*O_2^-$) and the hydroperoxide radical ($^*HO_2$) leads to the generation of the highly reactive hydroxl radical (*OH). The ozonide radical ion ($^*O_3^-$) is formed as an intermediate reaction product [11]. The pH value defined by $pH = -\log_{10}[H^+]$ is dependent on hydrogen ion [H^+] or hydroxide ion[OH^-]. A half-life time of ozone in aqueous solution was measured to be in the range from 2 min to 165 min depending on the conditions such as temperature, pH value and gas dynamics [11]. We observed increase of pH value of the mist water after the treatment. The ozone and its derivative radicals such as $^*O_2^-$,$^*HO_2$, *OH, $^*O_3^-$ enter the respiratory system of the aphid and give fetal damage to kill aphids .

The biological effects of ozone on plants have been studied under the air pollutant ozone and plants have evolved a complex of defense response mechanisms to respond various environmental stresses triggered by ozone. We studied the ozone-mist effect on tomato and eggplant.

management. Many kinds of aphids were tried for ozone-mist sterilization and biological effect on the sprayed pants were inspected. It was found that ozone derivative radicals in the ozone-mist play effective role on sterilization. Most of aphids were exterminated by 30 sec ozone-mist spraying.

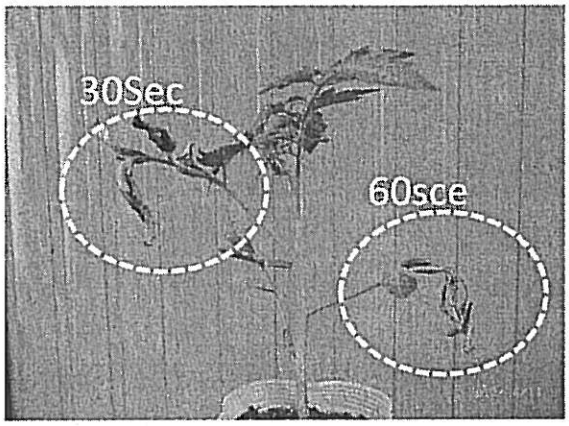

Fig.6 Photo of tomato leaves treated by ozone-mist during 30sec (left) and 60sec (right)

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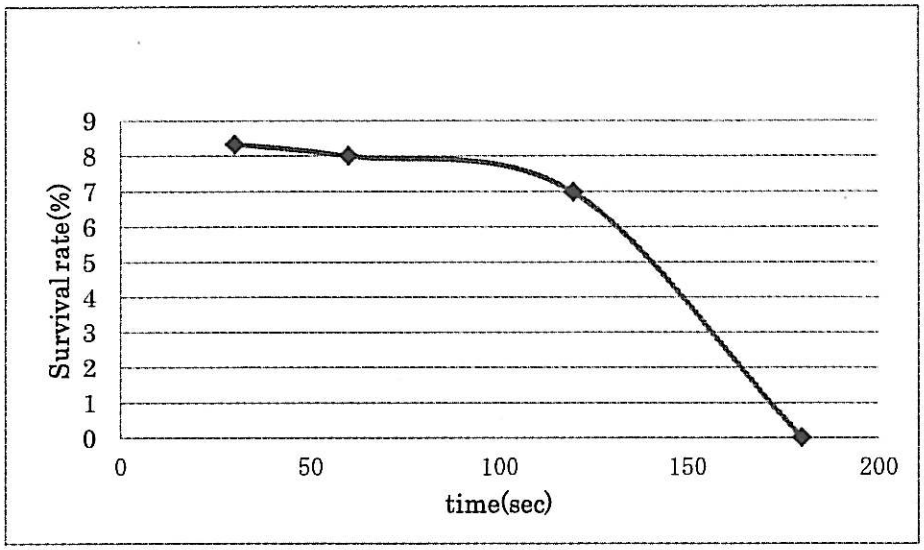

Fig.4 Survival rate of red aphid as a function of ozone-mist spraying time. Distance of ozone nozzle-sample is 50mm.

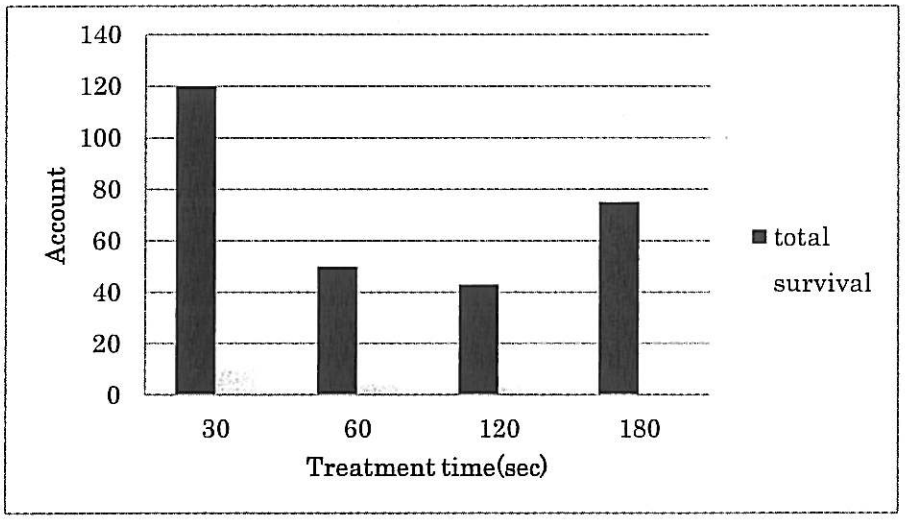

Fig.5 Survival number of aphids at various spraying times.

Figure 6 shows the picture of tomato young seedling. The left leaves and the right leaves were sprayed during 30 sec and 60 sec , respectively. We can notice remarkable damage on the leaves of young seeding. On the other hand, large eggplant sprayed by the similar conditions did not show noticeable damage. The stoma of plant is a pore in leaf and stem used for gaseous exchange. The microscopic measurement showed that the ozone-mist treatment gives serious damage on the stomata.

4. Conclusions

We have developed ozone-mist sterilization system to exterminate harmful insects in agricultural

2.Experimental

Figure 1 is the picture of the ozone-mist sterilization for agriculture. High dense ozone was generated by surface dielectric barrier discharge (1). The AC electric power to the high frequency generator was supplied from the AC-DC inverter (2) connected to Li-ion battery(3).

Figure 2 shows ozone concentration (g/m^3) as a function of oxygen gas flow rate. Maximum concentration of 86 g/m^3 was attained at a flow rate of 1 liter/min. Water mist was produced by supplying the water to the specific nozzle. The pump in the water container(4) to generate the mist was powered by Li-ion battery. High dense ozone was injected into the water mist through the gas nozzle. The ozone-mist generated near the nozzles was sprayed on the samples such as insects and plants.

The sterilization conditions was estimated by monitoring the dynamic behavior of aphids and observing the damage of agricultural plants (leaves of tomato and eggplant) when the ozone-mist was sprayed at various conditions of ozone concentration, mixture rate of ozone gas and water , their flow rates , spraying time and treatment location.

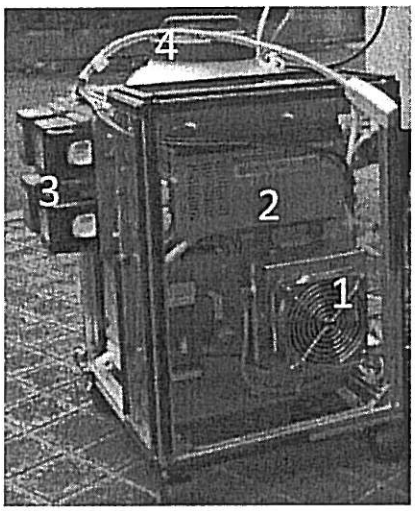

Fig.1 Ozone-mist sterilization system

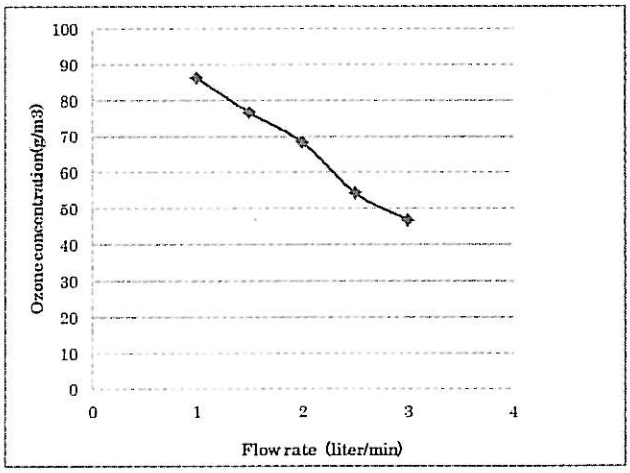

Fig.2 Ozone concentration characteristics of ozonizer.

We carried out the ozone-mist treatment for several insects, viruses and plants listed in Table 1.

Table 1. Insects, viruses and agricultural plants treated by ozone-mist spraying.

Insect	Virus	Plant
Aphid Red aphid(Uroleucon nigrotuberculatum) Cotton aphid (Gossypii glover) Crysanthermum aphid (Mocrosiphonella Sanbolnl) Rose aphid (Sitobion ibarae) Tobacco worm: Lasioderma serricorne (Fabricius) Green rice leaf hopper Caterpillar	Tobacco mosaic virus (TMV) Cucumber mosaic virus (CMV)	Tomato Eggplant Cucumber Tobacco

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