

Experiment of pest control with portable ozone mist device

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Abstract: We developed a portable ozone mist system for the pest control in a farm. Ozone has strong oxidation power and they seem effective for killing pests such as worms, and insects. To enhance their effect on the pest control, ozone gas is produced by the surface dielectric barrier discharge and mixed with water mist ejected from a nozzle. We investigated the killing effect of the ozone mist on aphids. The survival rate of the aphids was 3.3% for 5 sec treatment time.

1. Introduction

Pesticides were commonly used for the pest control in farms since they have high and rapid insecticidal effects and enable us to increase yields of crops. However, the pesticides cause some problems, soil and groundwater pollution and residual chemicals in crops harmful to consumers. In recent years, alternative methods to pesticides in the agriculture are required from the viewpoint of global environment and human health.

Ozone shows excellent sterilization effects and no persistent toxicity since it decomposes into oxygen within half an hour under normal condition. Ozone is free from environmental pollution and health damage as far as in proper usage. Ozone sterilization in the agriculture seems one of the promising techniques to secure the safety of foods. Ozone has been recognized as useful disinfectant and it is applied to the fields of water treatment and food processing. In the case of food processing, the ozone is used keeping the processed food fresh or preserving foods. In the case of water treatment, the ozone is applied to sterilize the tap water instead of chlorine. There is a research to remove pesticide residues in vegetables by using ozone water [1]. Ozonated water with low dissolved ozone level (1.4 mg/l) can effectively oxidize the four tested pesticides in aqueous solution under domestic conditions within 30 min and degradation was mostly completed within 5 min.

We examined a soil treatment or a pest control by the ozone [2] [3]. Ozone has been applied to various fields, but its application to the pest control has not been studied enough until now. In this paper, we suggest a portable ozone mist system for the pest control in the field of agriculture. This system also aims to prevent disease of crops caused by virus transmitted by pests. The system which has enough insecticidal ability can sterilize bacteria and viruses at the same time because they are less tolerant to ozone than pests. The mixture of ozone and water mist is produced by the nozzle system which we developed. Insecticidal effect of the portable ozone mist system

was examined by measuring survival rates of aphids treated by ozone mist. The target pests are red aphids which transmit the pathogenic virus such as the mosaic virus found in tobaccos and tomatoes fields.

2. Experimental setup

Figure 1 shows the portable ozone mist system which we developed. This system consists of an ozone generator, a DC-AC inverter, a water container, Li-ion batteries, and a small oxygen gas cylinder. The ozone gas, maximum concentration of 86 g/m³ at oxygen flow rate of 1 L/min, is generated by the surface dielectric barrier discharge. This system is designed



Fig.1 A portable ozone mist system
1. Ozone generator 2. DC-AC inverter 3. Water container 4. Oxygen cylinder

for the field use, so it can be carried and operate on the back without external power supply. Total weight of the system is 20 kg including the water tank filled with 5 L water. The ozone mist is generated the nozzle system which we developed. The ozone gas is fed through a central guide pipe outside. The water mist is sprayed around the ozone guide pipe to suppress the diffusion of ozone gas. Then ozone mist is generated by mixing the ozone gas with water mist.

Most of pathogenic viruses such as mosaic viruses are transmitted by aphids. Effect of ozone mist system is inspected by a survival rate of red aphids which is treated by ozone mist. The ozone-mist was sprayed at various conditions of ozone concentration, flow rates, spraying time and treatment location. Most of the experiments were performed at windless condition in the outdoor field.

3. Result and Discussion

Figure 2 shows discharge current waveform and voltage waveform of ozone generator.

Frequency and voltage of applied to the ozonizer were 10 kHz, and 4.5 kV, respectively. Discharge begins at voltage of approximately 2kV. The power of discharge measured by Lissajous diagram was 24.4 W.

Figure 3 shows ozone concentration as a function of oxygen gas flow rate. Ozone concentration decreased with increasing oxygen gas flow rate. The portable ozone mist system was operated at an oxygen flow rate of 1 L / min.

The results of the insecticidal experiment are as follows. The concentration of ozone gas produced by the surface dielectric barrier discharge was 86 g/m³ at oxygen gas flow rate of 1 L/min. The flow rate of water mist was 300 ml/min. The distance between the exit nozzle of ozone gas and aphids was $d = 50$ mm.

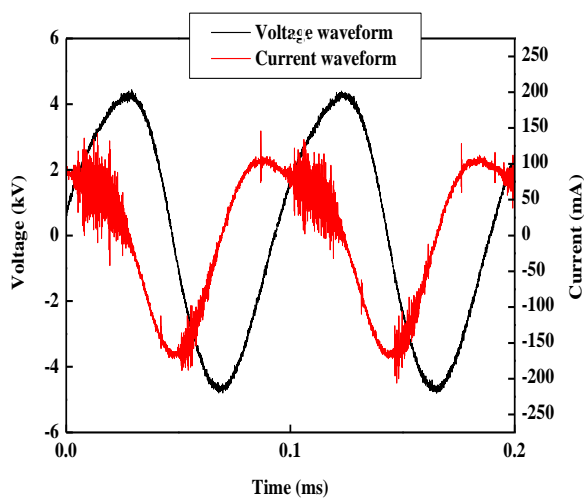


Fig.2 Waveforms of discharge current and voltage.

The aphids were exposed ozone mist for 5 sec and observed their behavior. Effect of ozone mist was evaluated by the survival rate of aphids, which is defined as the percentage of aphids without any motions. The survival rates were measured for three groups of aphids. Figure 4 shows the survival rates of aphids as a function of lapse time from sterilization. Large dispersion is found among the experiment. This may result from the different tolerance of aphids to ozone. Larger aphids have more immunity to ozone. The minimum survival rate after ozone mist treatment for 5 sec was about 3.3 %. The maximum survival rate was about 26.9 %. All aphids froze just after ozone mist was sprayed, therefore, survival rate at $t = 0$ was 0 in Fig.4 due to its definition. The aphids begin to move at $t = 30$ min or $t = 60$ min, after that, the survival rate kept constant or tended to decrease.

Considering the ozone concentration of 86 g/m³, flow rate of 1L/min and 5 seconds exposure time, the amount of ozone used was about 7.2 mg.

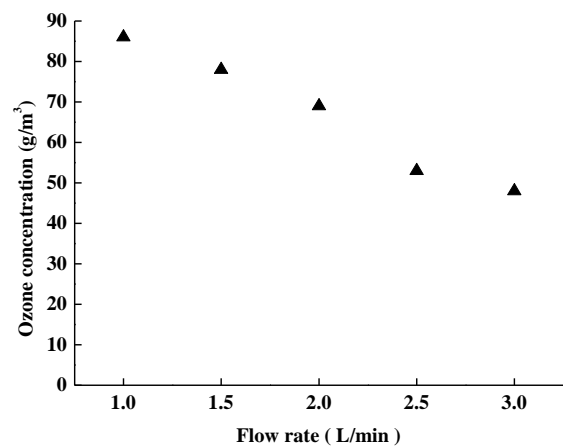


Fig.3 Ozone concentration as a function of oxygen gas flow rate.

Mist suppresses the diffusion of ozone gas, and the ozone gas is exposed aphids directly. Aphids have hydrophobic property and have the respiratory organs called the spiracle to take air into the body. In the case of using pesticides, spiracles of aphid are plugged by pesticides and then the aphids are suffocated. On the other hand, ozone gas fed into the body through spiracles causes cellular destruction. Therefore, exposing high concentration of ozone gas can be an effective pest control.

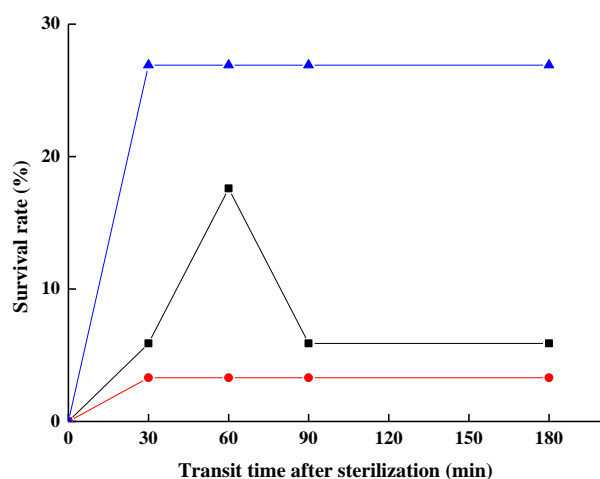


Fig. 4 Survival rate of red aphids vs. the transit time after sterilization.

We obtained enough insecticidal effects from these results. There is another study showing the effect on insects by high concentration of ozone gas. 100 % of the *P.interpunctella* adults were killed within 60 min when exposed to 500 ppm ozone [4]. Our study indicates that the pest control is possible in a very short time by using a high concentration ozone gas and the ozone mist nozzle system which we developed.

This system can become the promising insecticidal method in agriculture by shortening the treatment time more. Applications shortening the treatment time are currently under study.

4. Summary

We developed the portable ozone system and ozone mist nozzle system for the pest control used in an agriculture field and a green house. The concentration of ozone gas produced by the surface dielectric barrier discharge was 86 g/m^3 at oxygen gas flow rate of 1 L/min and the ozone mist is generated the nozzle system. The effects of the ozone mist spray sterilization on insects were investigated. The survival rate of aphids was about 3.3 % when ozone mist was exposed to aphids for 5 sec and enough insecticidal effects were confirmed. Our study indicates that the pest control is possible in a very short time by using a high concentration ozone gas and the ozone mist nozzle system which we developed. These system will be a promising insecticidal method in agriculture by shortening the treatment time.

5. Acknowledgements

This research was partly supported by Organization for Small & Medium Enterprises and Regional Innovation, JAPAN .

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