

## **EFFECTS OF GAS EXHAUSTED FROM GASOLINE ENGINE ON PLANTS GROWN IN THE GREENHOUSE**

**H. Sugimoto and J. Yamashita**

College of Agriculture, Ehime University, 3-5-7  
Tarumi, Matsuyama 790, Japan

### **ABSTRACT**

In order to establish a fully automatized pest control in the greenhouse, the authors developed a prototype of microcomputer installed spraying vehicle which traveled along the furrows. Since a power sprayer mounted on the vehicle was driven by gasoline engine, plants grown in the greenhouse might be injured by the gas exhausted from the engine. Thus, effects of exhausted gas on photosynthetic rate and the shedding of flowers and buds of plants were examined.

At first, effects of exhausted gas on photosynthetic rate of potted sweet pepper (Capsicum annuum L.) and eggplant (Solanum melongena L.) plants were examined. In a closed vinyl house the engine was operated for 5 minutes and plants were exposed to the gas for 2 hours in the daytime on a fine day. Photosynthetic rate did not significantly decreased by the treatment in both species.

Secondly, effects of ethylene on the shedding of flowers and buds of sesame (Sesamum indicum L.) were examined. In the closed and partially opened vinyl house, the engine was operated for 5 minutes and potted sesame plants were exposed to the gas for 12 hours in the night. In partially opened vinyl house, ethylene concentration decreased to 0 ppm 3 hours after the engine was stopped and flower and bud did not shed. In contrast, when vinyl house was closed ethylene concentration was 0.75 ppm even 12 hours after the engine was stopped and flowers and buds shed markedly and epinasty was observed in upper young leaves.

As mentioned above, it was revealed that injury of plants in the greenhouse caused by the gas exhausted from a gasoline engine could be prevented by providing suitable ventilation.

**Key Word** : Exhausted gas, Gasoline engine, Greenhouse, Pest control, Photosynthesis, Shedding of flowers and buds, Spraying vehicle

## INTRODUCTION

It is hard and dangerous for the farmer to spray pesticides in the greenhouse. In order to establish a fully automatized pest control in the greenhouse, the authors developed a prototype of microcomputer installed spraying vehicle which traveled along the furrows "Yamashita et al. (1991)". Since a sprayer mounted on the vehicle was driven by a gasoline engine, plants grown in the greenhouse might be injured by the gas exhausted from the engine.

Exhausted gas from a gasoline engine contains pollutants such as SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub>. Photosynthetic rate of plants exposed to these pollutants was reduced "Bull and Mansfield (1974), Taniyama (1972, 1976)". Also exhausted gas contains ethylene. Ethylene is one of the plant hormone. In response to ethylene plants are brought about shedding of flowers and buds "Crocker and Knight (1908)" and epinasty (the upper surface of foliage leaf develops more vigorous than the lower, causing a downward curvature) "Neljubow (1901)". In this study, the effects of exhausted gas on photosynthetic rate and the shedding of flowers and buds of plants grown in the greenhouse were examined.

## MATERIALS AND METHODS

At first, effects of exhausted gas on photosynthetic rate of sweet pepper (Capsicum annuum L.) and eggplant (Solanum melongena L.) were examined. The seedlings were transplanted on 10 May 1992 in pots and 60 days after the transplanting, plants were used for the experiments. In the daytime on a fine day, plants were carried into the closed vinyl house (42m<sup>2</sup>) and the engine was operated for 5 minutes at the rate of 3,000 rpm. Plants were exposed to the gas for 2 hours. Photosynthetic rate of whole plant were determined just before and 24 hours after the end of the treatment with the use of an infrared gas analyzer and assimilation chamber (50×50×50 cm). Metal halide lamps (Toshiba, RD-400) filtered through 10 cm of water provided a light intensity of 1,000 μEm<sup>-2</sup>s<sup>-1</sup>. Air temperature in the chamber and leaf temperature were kept at 30.0 ± 1.0°C and 30.5 ± 1.5°C, respectively and relative humidity in the chamber was 57 ± 3%. In this experiment, concentration of pollutants such as SO<sub>2</sub>, NO<sub>2</sub>, O<sub>3</sub> were not measured.

Secondly, effects of ethylene on the shedding of flowers and buds of sesame (Sesamum indicum L.) were examined. Sesame plants

are used as an indicator to ethylene pollution "Taniyama and Koike (1978)". The seeds were sown on 10 July 1992 in pots and 44 days after the sowing, plants were used for the experiment. Sesame plants were carried into the closed and partially opened (one side of vinyl house was opened and opened area was about 1% of whole surface) vinyl house. The engine was operated for 5 minutes at the rate of 3,000 rpm and plants were exposed to the gas for 12 hours in the night. The number of flowers and buds were counted 24 and 48 hours after the treatment. Air in the vinyl house was sampled at the height of 1m and ethylene concentration was determined with a gas chromatography

## **RESULTS AND DISCUSSION**

### **1. Outline of the spraying vehicle**

The prototype is a four-wheeled vehicle, and its rear wheels are driven independently by 12 V, 116 W DC printed-circuit motors incorporated in tire wheel (Fig.1). This vehicle is equipped with the following control functions. To prevent the vehicle from running on the ridges, the vehicle was equipped with the steering system of mechanical heading control unit for autonomous traveling. The route and direction of the vehicle is controlled by optical sensors mounted on it. A power sprayer, a pesticides tank and nozzles are mounted on the vehicle. A power sprayer is driven by a gasoline engine (4 cycles, 77.6 ml). Relationship between rotation rate and ethylene concentration exhausted from the engine were shown in Table 1. Ethylene concentration increased with increasing of the rotation rate. The engine was operated at the rate of 3,000 rpm in this study.

### **2. Effects of exhausted gas on photosynthetic rate**

Effects of gas on photosynthetic rate are shown in Fig. 2. Photosynthetic rate measured 24 hours after the end of the treatment were not significantly different from that measured just before the treatment. It might be possible that photosynthetic rate decreased during the treatment. However, the results suggested that even if photosynthetic rate decreased during the treatment, it entirely recovered 24 hours after the end of the treatment. Visible injuries were not observed in both species. Results of this experiment indicated that photosynthesis were not impeded when plants were exposed to the gas exhausted from a

gasoline engine within 2 hours.

### **3. Effects of ethylene on shedding of flowers and buds**

Changes of ethylene concentration in the vinyl houses are shown in Fig. 3. Ethylene concentration in the partially opened vinyl house decreased to 0 ppm 3 hours after the engine was stopped, however the concentration in the closed vinyl house was 0.75 ppm even 12 hours later.

The changes in number of flowers and buds 24 and 48 hours after the end of the treatment are shown in Table 2. Flowers and buds did not shed in the partially opened vinyl house. The increase in the control plants 24 and 48 hours after the end of the treatment were 2.9% and 5.9%, respectively and those of partially opened vinyl house were 3.6% and 6.6%, respectively. There were not significant difference between two treatments in increase in number of flowers and buds. On the other hand, flowers and buds shed remarkably in the closed vinyl house. The increase in number of flowers and buds 24 and 48 hours after the end the treatment were -6.8% and -13.8%, respectively. Upper leaves showed epinasty in this treatment (Fig. 4). In the closed vinyl house condition, yield of sesame is likely to decrease markedly.

Taniyama and Koike (1978) reported that ethylene induced shedding of flowers and buds of sesame was influenced by the concentration of ethylene and duration of treatment. They observed that subjecting plants to lower concentration of ethylene (0.05 ppm) for a long time (beyond 4 hours) resulted in remarkable shedding of flowers and buds; but at higher concentration (5 ppm) and short duration (within 2 hours), flowers and buds were not shed. In this experiment, ethylene concentration rose to 2 ppm just after the engine was stopped in the partially opened vinyl house, however 3 hours later it decreased to 0 ppm. It was assumed that as ethylene concentration decreased to 0 ppm within 3 hours, flowers and buds were not shed in this treatment.

The results of this study suggest that the injury of plants grown in the greenhouse caused by the gas exhausted from a gasoline engine could be prevented by providing suitable ventilation.

### **CONCLUSIONS**

Effects of the gas exhausted from gasoline engine on plants were

examined. Photosynthetic rates of sweet pepper and eggplant were not significantly decreased when plants were exposed to the gas within 2 hours. Sesame plant did not shed its flowers and buds when ethylene concentration decreased to 0 ppm within 3 hours. It was revealed that the injury of plants grown in the greenhouse caused by the gas exhausted from a gasoline engine could be prevented by providing suitable ventilation.

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Table 1. Relationship between rotation rate of the gasoline engine\* and ethylene concentration contained in the exhausted gas.

Rotation rate	Ethylene concentration
rpm	ppm
2,000	77.9
2,500	85.6
3,000	96.0
3,500	116.5
4,000	136.6

\* 4 cycles, 77.6 ml.

Table 2. Changes in the number of flowers and buds of sesame.

Treatment	Initial number	24 hours after \$	48 hours after \$
Control	34.0 ± 3.7*	35.0 ± 3.6 (102.9) §	36.0 ± 3.7 (105.9)
Partially opened	33.2 ± 4.0	34.4 ± 2.4 (103.6)	35.4 ± 2.7 (106.6)
Closed	33.4 ± 3.0	31.0 ± 2.5 ( 93.2)	28.8 ± 2.6 ( 86.2)

\$ 24 and 48 hours after the end of the treatment.

\* Data are means (±SE) for 5 plants.

§ Percentage to the initial number.

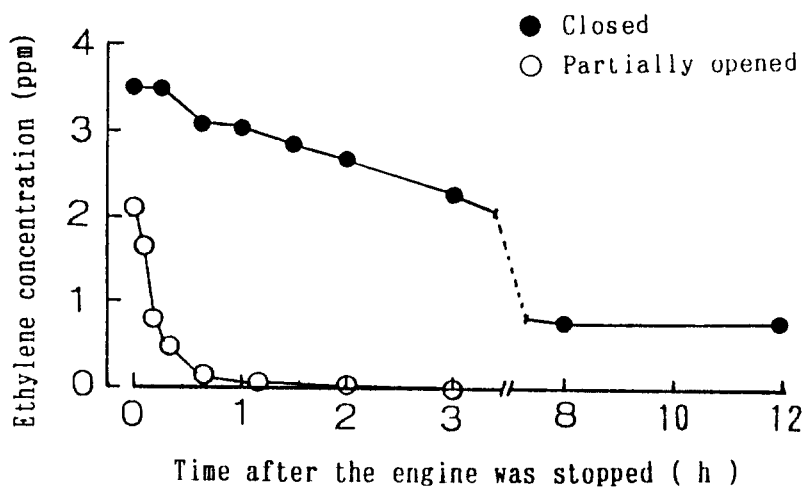


Fig. 3. Changes in the ethylene concentration contained in the gas exhausted from the gasoline engine in the closed and prtially opened vinyl house.

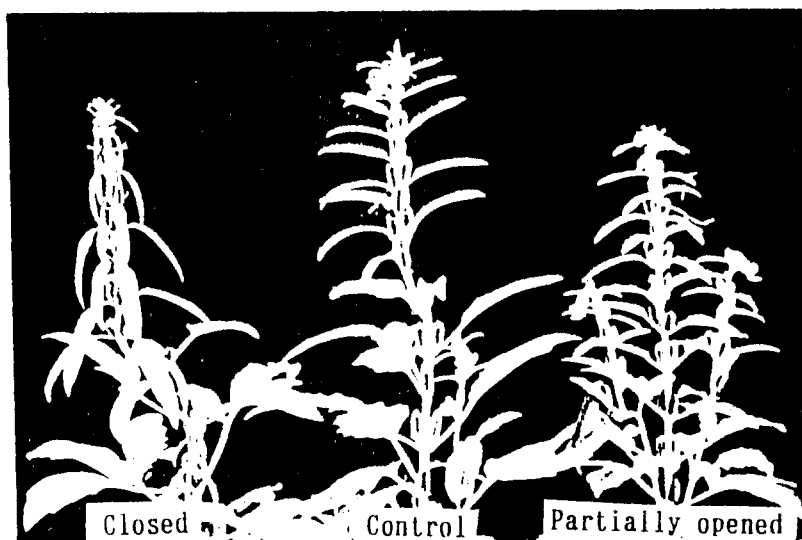


Fig. 4. Effects of ethylene contained in the gas exhausted from the gasoline engine on sesame plant. Plant treated in the closed vinyl house showed marked epinasty in upper young leaves.

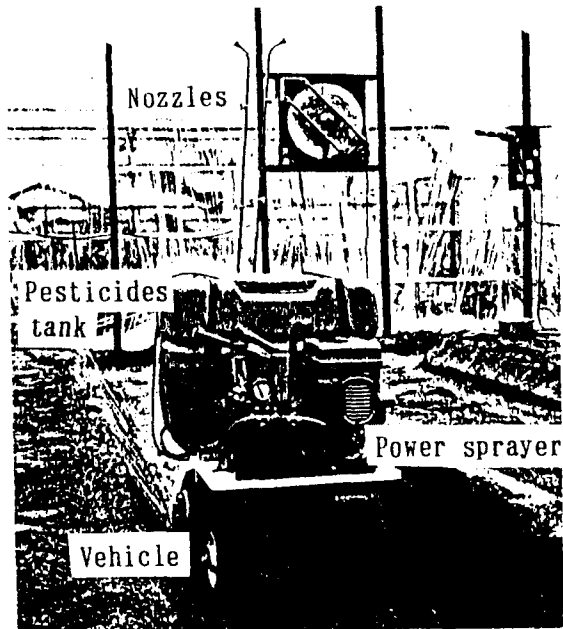


Fig. 1. The spraying vehicle. A power sprayer, a pesticides tank and nozzles are mounted on the vehicle. The power sprayer is driven by the gasoline engine.

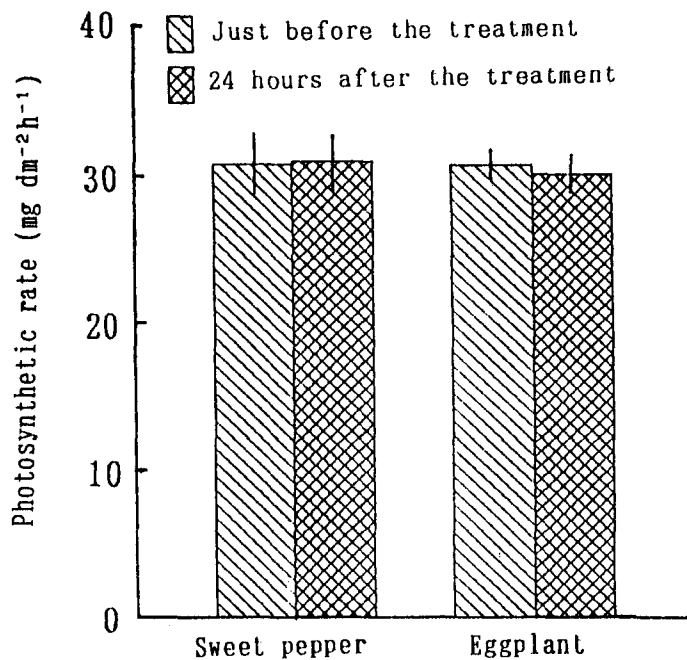


Fig. 2. Effects of the gas exhausted from the gasoline engine on photosynthetic rates of sweet pepper and eggplant. Photosynthetic rates of whole plant were measured with assimilation chamber under  $1,000 \mu\text{E m}^{-2}\text{s}^{-1}$  and  $30.0 \pm 1.0^\circ\text{C}$ . Data are means ( $\pm\text{SE}$ ) for 6 plants.