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DEVELOPMENT OF EFFICIENT CO₂ ENRICHMENT TECHNIQUE BASED ON A SIMPLE PHOTOSYNTHESIS MODEL OF STRAWBERRIES

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ABSTRACT

In Japanese strawberry production, environmental control in greenhouses is carried out to increase yields and improve fruit quality. CO₂ enrichment technique, which promotes leaf photosynthesis by supplying CO₂ gas generated by burning kerosene inside greenhouses, has become an indispensable technique in strawberry cultivation. However, conventional CO₂ enrichment involves continuous supplementation over a long period of time regardless of the photosynthetic response of strawberries, and the excessive use of fuels resulting from this practice is a problem. In this study, we investigated the effects of new CO₂ enrichment method based on a simple photosynthesis model on yield and fuel consumption. Based on photosynthesis measurements of strawberry leaves, we developed a simple photosynthesis model that enables the calculation of photosynthetic rates using two variables: light intensity (*PPFD*) and CO₂ concentration. Using this model, we set the *PPFD* value at which the photosynthetic rate reaches 40% of its maximum as the threshold: 150 μmol m⁻² s⁻¹. In the model-based CO₂ treatment, CO₂ concentration was controlled at 1,000 μmol mol⁻¹ when *PPFD* was above the threshold, and CO₂ supply was turned off when *PPFD* was below the threshold. The model-based CO₂ treatment was compared with the normal CO₂ treatment, where CO₂ concentration was constantly controlled at 1,000 μmol mol⁻¹ during daytime, to investigate differences in yield and fuel usage. The fruit yield in the model-based CO₂ treatment was almost same with that in the normal CO₂ treatment. Fuel consumption was approximately 17% lower in the model-based CO₂ treatment compared to the normal CO₂ treatment. This suggests that precise CO₂ enrichment based on a simple photosynthesis model may improve fuel use efficiency of CO₂ enrichment in strawberry productions.

Keywords: CO₂ enrichment, Fuel use, Photosynthesis model, Strawberry, Yield.

INTRODUCTION

CO₂ enrichment, which uses fossil fuels, requires optimization of the space and timing of supplementation. While crop-local CO₂ supply technique has been developed (Hidaka *et al.*, 2022), effective timing of supply has yet to be studied. In this study, we investigated an effect of new CO₂ enrichment method altering supplementation timing based on a simple photosynthesis model on yield and fuel consumption in cultivation of strawberries.

MATERIALS AND METHODS

Nursery plants of June-bearing strawberry 'Benihoppe' were transplanted in mid-September at 20 cm plant spacing, and the experiment was conducted until the end of May. Based on photosynthesis measurements of strawberry leaves, we developed a simple photosynthesis model that enables the calculation of photosynthetic rates using two variables: light intensity (*PPFD*) and CO₂ concentration. Using this model, we set the *PPFD* value at which the photosynthetic rate reaches 40% of its maximum as the threshold: 150 $\mu\text{mol m}^{-2} \text{s}^{-1}$. In the model-based CO₂ treatment, CO₂ concentration was controlled at 1,000 $\mu\text{mol mol}^{-1}$ when *PPFD* was above the threshold, and CO₂ supply was turned off when *PPFD* was below the threshold. The model-based CO₂ treatment was compared with the normal CO₂ treatment, where CO₂ concentration was constantly controlled at 1,000 $\mu\text{mol mol}^{-1}$ during daytime, and non-treatment to investigate differences in yield and fuel consumption. CO₂ treatment was continuously conducted from December to the next April.

RESULTS & DISCUSSION

In the model-based CO₂ treatment, CO₂ gas was supplied only when *PPFD* exceeded the threshold value of 150 $\mu\text{mol m}^{-2} \text{s}^{-1}$ (Fig. 1). Meanwhile, CO₂ concentrations in normal CO₂ treatment were maintained around 1,000 $\mu\text{mol mol}^{-1}$ during 6:00–18:00. Yields of strawberry fruits increased by 1.2 times in the normal CO₂ treatment compared to the non-treatment, and by 1.3 times in the model-based CO₂ treatment (Fig. 2). The fuel consumption for CO₂ enrichment was 1,226 L in the normal CO₂ treatment and 1,018 L in the model-based CO₂ treatment, and the value in the model-based CO₂ treatment was approximately 17% lower than that in the normal CO₂ treatment (Fig. 3). Thus, the precise CO₂ enrichment based on a simple photosynthesis model may improve fuel use efficiency due to yield increase and fuel consumption decrease in strawberry productions.

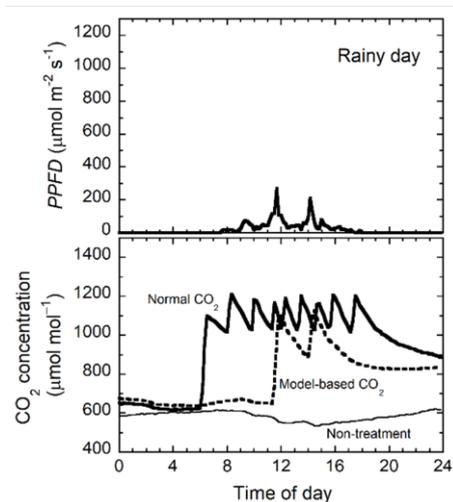


Fig.1 Diurnal changes in *PPFD* and CO₂ concentration in each treatment

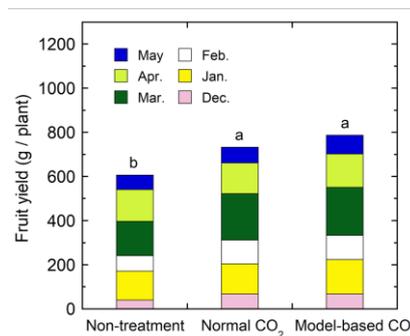


Fig.2 Fruit yield in each treatment

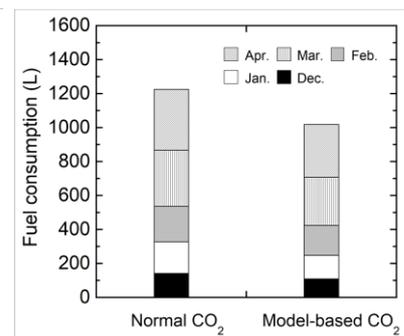


Fig.3 Fuel consumption in each treatment

REFERENCES

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