INTRODUCTION

The production of reactive oxygen species in the chloroplast is an inevitable consequence of the photodynamic processes that occur. Singlet oxygen (\(O_2^+\)) and oxygen radicals such as superoxide anion (\(O_2^-\)) are responsible for photooxidative damage to pigments, lipids, and proteins. Singlet oxygen is produced when oxygen quenches triplet chlorophyll. Protection from \(O_2^+\) is offered by the carotenoids which quench both \(O_2\) and triplet chlorophyll (1). Superoxide anions are produced at the reducing side of photosystem I, either by reaction with P430, an insoluble electron acceptor, (2) or with ferredoxin (3). The latter reaction is known as the Mehler reaction. Superoxide anions are detoxified in the chloroplast by a series of reactions (4):

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\begin{align*}
2 \text{O}_2^+ + 2 \text{H}^+ & \xrightarrow{\text{superoxide dismutase}} \text{O}_2 + \text{H}_2\text{O}_2 \\
1/2 \text{H}_2\text{O}_2 + \text{Asc} & \xrightarrow{\text{ascorbate peroxidase}} \text{H}_2\text{O} + \text{MDA} \\
2 \text{MDA} & \xrightarrow{\text{(nonenzymatic)}} \text{Asc} + \text{DHA} \\
2 \text{MDA} + \text{NADPH} + \text{H}^+ & \xrightarrow{\text{MDA reductase}} 2 \text{Asc} + \text{NADP}^+ \\
\text{DHA} + 2 \text{GSH} & \xrightarrow{\text{DHA reductase}} \text{Asc} + \text{GSSG} \\
\text{GSSG} + \text{NADPH} + \text{H}^+ & \xrightarrow{\text{glutathione reductase}} 2 \text{GSH} + \text{NADP}^+
\end{align*}
\]

where

- Asc = ascorbic acid
- MDA = monodehydroascorbic acid
- DHA = dehydroascorbic acid
- GSH = reduced glutathione
- GSSG = oxidized glutathione

In this report, a mutant of Arabidopsis thaliana is described which was isolated based on a growth requirement for elevated CO\(_2\). Somerville and Ogren (5) described six classes of Arabidopsis mutants isolated in a similar fashion that had defects in enzymes, or in one case a transport protein, of the photorespiratory pathway. The mutant described in this report, however, has unaltered carbon metabolism but displays photooxidation in air.

RESULTS

Description and Photosynthetic Properties of the Mutant

The mutant (designated CS208) is slightly bleached but otherwise
healthy when grown in air containing 1-2% CO₂. However, chlorophyll and carotenoid content is reduced by 50% after 5 days of continuous illumination in air (Fig. 1). When the mutant is returned to high CO₂, the chlorotic tissue does not regain normal pigmentation.

![Figure 1. Destruction of pigments in CS208 in air. A, chlorophyll; B, carotenoids. ■, □ Wild type; ●, ○ CS208; closed symbols depict samples from 2% CO₂; open symbols depict samples from air. Chlorophyll and carotenoids were measured in 80% acetone according to MacKinney (6) and Kirk and Allen (7).](image-url)

Photosynthetic gas exchange in 21% O₂, 350 ppm CO₂, was measured on wild type and mutant plants grown in high CO₂. The rate of photosynthesis was similar in wild type and mutant when expressed on a protein, leaf area or fresh weight basis (Table 1). Gas exchange remained remarkably stable for 20 hours in both mutant and wild type.

Wild type and mutant plants were labeled with ¹⁴CO₂ either during induction of photosynthesis or during steady state photosynthesis. The distribution of ¹⁴C label in the mutant was very similar to wild type (not shown). The gas exchange data together with the ¹⁴C labeling data indicate that photosynthetic carbon metabolism is not altered in the mutant.

Electron transport was measured using various donors and acceptors to assay whole chain, photosystem I, or photosystem II activity. There was