Plant, Cell and Environment (1998) **21,** 1153-1161

Photosynthetic down-regulation in *Larrea tridentate* exposed to elevated atmospheric CO_2: interaction with drought under glasshouse and field (FACE) exposure

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Abstract The photosynthetic response of *Larrea tridentata* Cav., an evergreen Mojave Desert shrub, to elevated atmospheric CO_2 and drought was examined to assist in the understanding of how plants from water-limited ecosystems will respond to rising CO_2. We hypothesized that photosynthetic down-regulation would disappear during periods of water limitation, and would, therefore, likely be a seasonally transient event. To test this we measured photosynthetic, water relations and fluorescence responses during periods of increased and decreased water availability in two different treatment implementations: (1) from seedlings exposed to 360, 550 and 700 μmol mol^{-1} CO_2 in a glasshouse; and (2) from intact adults exposed to 360 and 550 μmol mol^{-1} CO_2 at the Nevada Desert FACE (Free Air CO_2 Enrichment) Facility. FACE and glasshouse well-watered *Larrea* significantly down-regulated photosynthesis at elevated CO_2, reducing maximum photosynthetic rate (A_{max}), carboxylation efficiency (CE), and Rubisco catalytic sites, whereas droughted *Larrea* showed a differing response depending on treatment technique. A_{max} and CE were lower in droughted *Larrea* compared with well-watered plants, and CO_2 had no effect on these reduced photosynthetic parameters. However, Rubisco catalytic sites decreased in droughted *Larrea* at elevated CO_2. Operating C_i increased at elevated CO_2 in droughted plants, resulting in greater photosynthetic rates at elevated CO_2 as compared with ambient CO_2. In well-watered plants, the changes in operating C_i, CE and A_{max} resulted in similar photosynthetic rates across CO_2 treatments. Our results suggest that drought can diminish photosynthetic down-regulation to elevated CO_2 in *Larrea*, resulting in seasonally transient patterns of enhanced carbon gain. These results suggest that water status may ultimately control the photosynthetic response of desert systems to rising CO_2.