Interactive Effects of Elevated CO_2 and Ozone on Leaf Thermotolerance in Field-grown *Glycine max*

Anthropogenic increases in atmospheric carbon dioxide (CO_2) are a major contributor to increased global mean surface temperature. Mean temperature increases will be accompanied by increases in the frequency, duration, and severity of periods with unusually high temperatures (i.e., heat waves or acute heat stress). Increases in heat waves are likely to have significant ecological impact, including decreasing primary production and biodiversity and altering community composition and function. Elevated CO_2, relative to current CO_2 levels, has been demonstrated to affect plant tolerance (photosynthetically) to acute heat stress.

The objective of this study was to investigate the effects of elevated CO_2 on plant tolerance to acute heat stress in field-grown plants, and also examine the effects of ozone (O_3) and its interaction with CO_2 on heat tolerance. *Glycine max* was grown under Free Air Concentration (CO_2 and O_3) Enrichment (FACE). The leaves of heat-stressed plants in the field were attached, but in the lab, heat stress was imposed on detached leaves harvested from plants in the field. Both lab and field samples were monitored for the effects of heat stress, CO_2, and O_3 on photosynthetic electron transport (Φ_{et}), as well as pigment, heat-shock protein (HSP), carbohydrate, and enzyme content.

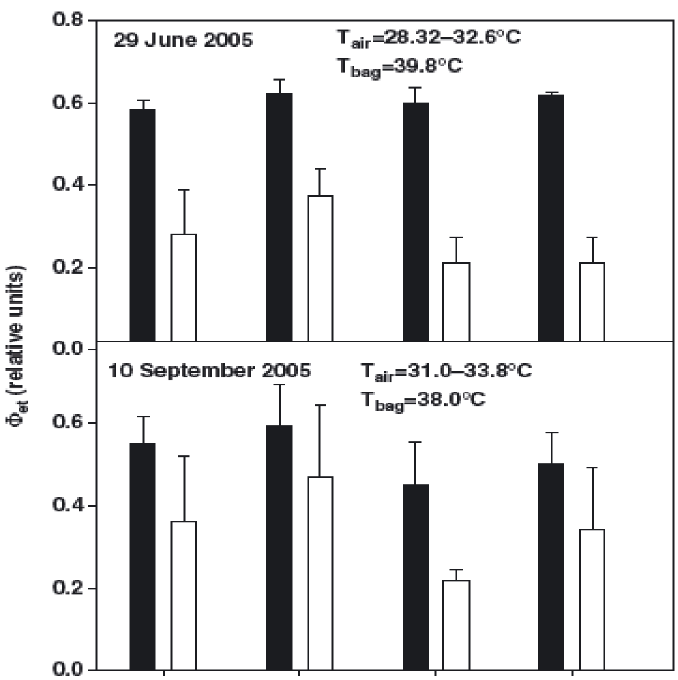

Figure 1. Effect of elevated (+) CO_2 and O_3 on *in situ* thermotolerance of photosynthetic electron transport (Φ_{et}) on control (■) and heat-stressed (□) leaves of field-grown soybean plants. Ambient air temperatures during the heat treatment and temperatures of bags/leaves at time of measurements indicated in panels. Results are means (± *SD*) of four plots within each treatment combination, and plot means were based on three replicates within each plot.

Acute heat stress decreased Φ_{et}, which O_3 exacerbated (Figure 1). Elevated CO_2 prevented O_3-related decreases during heating, but only increased Φ_{et} under ambient O_3 in the field. Heat stress decreased chlorophyll and carotenoids, especially under elevated CO_2. Neither CO_2 nor O_3 affected heat-shock proteins (Figure 2). Soluble carbohydrates were unaffected by heating, but increased in elevated CO_2. Heating increased catalase (except in high O_3) and Cu/Zn-superoxide dismutase (SOD), but not Mn-SOD; CO_2 and O_3 decreased catalase but neither SOD.

Protection of photosynthesis during heat stress by elevated CO_2 occurs in field-grown soybean under ambient O_3, as in the lab. High CO_2 limits heat damage under elevated O_3, but this protection is likely from photorespiration and stomatal conductance rather than production of heat-stress adaptations.

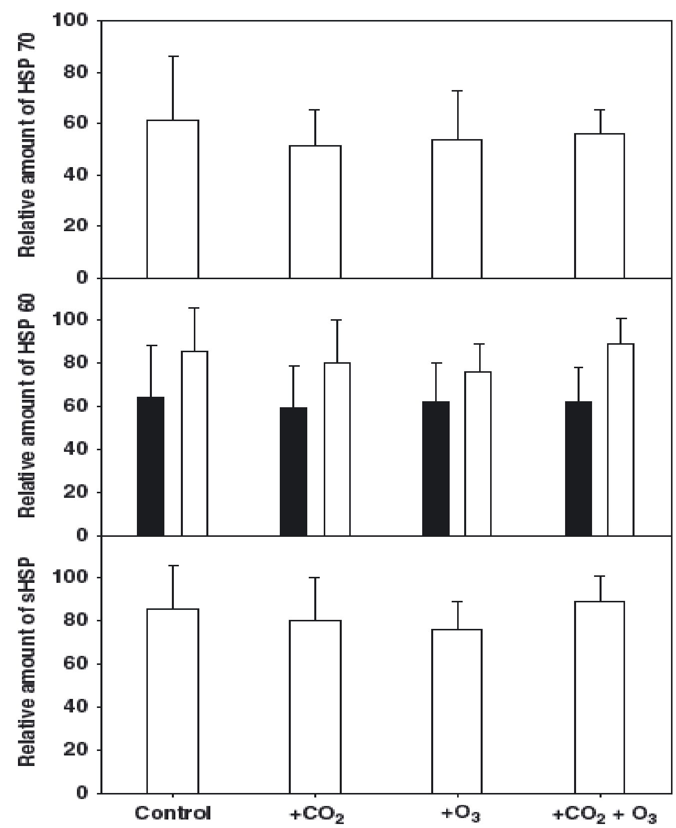

Figure 2. Effect of elevated (+) CO_2 and O_3 on heat-shock protein (HSP=sum of HSP 70, HSP 60, and small sHSP) content of control (■) and heat-stressed (□) soybean leaves. Results are means (±SD) of three replicates. Protein content is expressed as a percent of a standard (heat-shocked) leaf extract.

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