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Episodes of high tropospheric ozone reduce nodulation, seed production and quality in soybean (*Glycine max* (L.) merr.) on low fertility soils☆

Lucio Biancari [a, *], Clara Cerrotta [a, b], Analía I. Menéndez [a], Pedro E. Gundel [a, c], M. Alejandra Martínez-Ghersa [a]

[a] IFEVA, Universidad de Buenos Aires, CONICET, Facultad de Agronomía, Buenos Aires, Argentina
[b] Universidad Nacional de Hurlingham, Instituto de Biotecnología, Villa Tesei, Buenos Aires, Argentina
[c] Instituto de Ciencias Biológicas, Universidad de Talca, Campus Talca, Chile

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ABSTRACT

Driven by human activities, air pollution and soil degradation are threatening food production systems. Rising ozone in the troposphere can affect several physiological processes in plants and their interaction with symbiotic microorganisms. Plant responses to ozone may depend on both soil fertility and the ontogenetic stage in which they are exposed. In this work, we studied the effects of ozone episodes and soil fertility on soybean plants. We analysed soybean plant responses in the production of aboveground and belowground biomass, structural and functional attributes of rhizobia, and seed production and quality. The experiment was performed with plants grown in two substrates with different fertility (commercial soil, and soil diluted (50%, v/v) with sand). Plants were exposed to acute episodes of ozone during vegetative and reproductive stages. We observed that ozone significantly reduced belowground biomass (≈25%), nodule biomass (≈30%), and biological nitrogen fixation (≈21%). Plants exposed to ozone during reproductive stage growing in soil with reduced fertility had lower seed production (≈10% lower) and seed protein (≈12% lower). These responses on yield and quality can be explained by the observed changes in belowground biomass and nitrogen fixation. The negative impact of ozone on the symbiotic interaction with rhizobia, seed production and quality in soybean plants were greater in soils with reduced fertility. Our results indicate that food security could be at risk in the future if trends in ozone concentration and soil degradation processes continue to increase.

Author contribution

Lucio Biancari: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Clara Cerrotta: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Analía I. Menéndez: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, Pedro E. Gundel: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing, M. Alejandra Martínez-Ghersa: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing.

1. Introduction

High concentrations of tropospheric ozone (O_3) impair primary productivity in a variety of agro-ecosystems (Ainsworth et al., 2020; Karlsson et al., 2017; Mills et al., 2011). Although models project that concentrations of tropospheric ozone will continue to increase mainly due to human activities, they present highly variable dynamics (Grewe et al., 2001; Hauglustaine and Brasseur, 2001; Monks et al., 2015). Following the dynamics of solar radiation, O_3 in the troposphere displays temporal variations within the day and during the year, with peaks of high concentrations at noon and in summer, respectively (Ainsworth et al., 2020). Ozone is

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* Corresponding author. IFEVA, Universidad de Buenos Aires, CONICET, Facultad de Agronomía, Av. San Martín 4453, Buenos Aires, C1417DSE, Argentina.
E-mail address: biancari@agro.uba.ar (L. Biancari).

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