Impact of elevated ozone on gas exchange and yield of wheat (*Triticum aestivum* L.): meta-analysis

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Abstract: Ozone is currently considered to be the most important air pollutant in many parts of Europe, North and Central America and the East Asia, mainly because current ambient [O3] in these areas are observed to induce significant yield losses such as wheat, potato, soybean. However, the detrimental effects of ozone are dependent on the genetic background, development stage of the plants, O3 doses, fumigation method, and soil water and nutrient conditions. Up to date, a large number of studies have investigated the response of wheat growth, physiology and yield to elevated [O3] and other environmental factors. Is there a means to determine quantitatively the mean responses of wheat growth and production to the current and future elevation of [O3] across all factors?

Meta-analyses provide an approach to estimate a mean relative response quantitatively from diverse data source and experiments. This approach compiled divergent reported value into estimate of the mean effect size. We quantitatively evaluated the effects of elevated ozone (O3) on growth, gas exchange and grain yield by means of meta-analysis. Our database consisted of 53 peer-reviewed studies between 1980 and 2007, taking into account wheat type, ozone fumigation method, rooting environment, ozone concentration, developmental stage, additional treatments such as drought and elevated [CO2]. Results suggested that the elevation of [O3] is depressing yield and above-ground biomass by 29% (CI 24-34%) and 18% (13-24%), respectively, where CI is the 95% confidence interval. Even in studies where average [O3] 43 ppb with a range of 31-50 ppb, there was a significant decrease in yield (18%) and biomass (16%). There was no significant response difference between spring wheat and winter wheat. Wheat grown in field or open-top chamber showed larger decreases in some variables induced by elevated [O3]. The higher the average daily [O3], the greater the detrimental effect, with very few exceptions. The impact of ozone increased with developmental stages, with the largest decrease in grain filling. Both drought and elevated [CO2] significantly ameliorate the detrimental effects of elevated [O3], which could be explained by a significant decrease in ozone uptake.

Key-words: air pollution; atmospheric change; biomass; elevated [CO2]; global change; grain quality; ozone; photosynthesis; stomata; yield component