Responses of C₄ Waterhemp and C₃ Cotton to Ozone and Moisture Stress: Contribution to a Developing Weed Problem?

Rama Paudel¹, Hai-Bang Vu², Nancy Grulke³, David A. Grantz², and Anil Shrestha¹,
¹Department of Plant Sciences, California State University, Fresno
²Department of Botany and Plant Sciences, University of California, Riverside
³USDA Forest Service, Prineville, OR

Tropospheric ozone (O₃) is a major air pollutant and an important anthropogenic stressor in agricultural cropping systems of the Central Valley of California. Studies have reported that O₃ can have differential effects on crops and weeds and thereby alter crop-weed competition dynamics in some crops. Some weeds like black nightshade (Solanum nigrum), horseweed (Conyza canadensis), and yellow nutsedge (Cyperus esculentus) have been found to be tolerant to O₃ and in some cases more competitive with crops in elevated O₃ condition. Common waterhemp (Amaranthus tuberculatus) is a problematic weed in the Midwest soybean and corn production systems. Although it is not a widespread weed in California, it has been reported in some counties such as San Diego, Santa Barbara, and Sacramento. Preliminary studies showed that some populations of this weed species were tolerant to glyphosate at later growth stages (beyond 6” size). Due to its ability to spread rapidly and tolerance to glyphosate at later-stages, common waterhemp could be a potential weed in the Central Valley and other parts of California. Further, availability of water for irrigation is a challenge in the Central Valley and it has resulted in an increased interest in research on regulated deficit irrigation (RDI) in several cropping systems. However, it is not known how this weed species would adapt to elevated O₃ levels and reduced moisture conditions. Knowledge of the response of common waterhemp to these environmental conditions would help predict the invasive potential of this weed in the Central Valley. Therefore, a study was conducted to determine the effect of different O₃ levels and reduced irrigation on common waterhemp. The study was conducted in controlled O₃ environments in continuously stirred tank reactor (CSTR) chambers. The growth and stomatal conductance (day and night) of cotton (Gossypium hirsutum) and common waterhemp in these chambers were compared in a split-plot design with O₃ as main effect and irrigation as sub-effect. The main plots consisted of three different concentrations of 12 hour mean exposure to O₃ (15ppb: low O₃, 80ppb: medium O₃, and 150 ppb: high O₃) and the sub-plots consisted of two irrigation levels (control and reduced). The experiment was conducted twice (in early and late summer of 2013). Ozone and irrigation level had a significant (P<0.05) effect on the day and night time stomatal conductance of cotton but not on common waterhemp. Day time stomatal conductance decreased while night time stomatal conductance increased in cotton as O₃ concentration increased. Similarly, while increasing O₃ and reduced irrigation level significantly decreased the above- and below-ground biomass of cotton, these variables had no effect on common waterhemp. Our results suggest that common waterhemp can be more invasive and more competitive with crops under high O₃ and deficit irrigation conditions in the Central Valley. The problem can be more serious if this weed evolves resistance to glyphosate. Therefore, the spread of this weed needs to be monitored carefully so that it does not become a serious threat in the Central Valley as in other parts of the country.