Differential Responses of Crop and Weed to Ozone and Moisture Stress: A Potential Perturbation of Crop-Weed Competition.

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SUMMARY:

➢Tropospheric ozone (O_3) is a stressor of natural and managed vegetation. Climate change is altering hydrological systems.O_3 impact on nocturnal stomatal conductance (gs) has been suggested to increase transpiration and alter hydrology.

➢Elevated O_3 and water deficit are more deleterious to some crops than to weeds. The combined effects on crops and weeds are not known. Night-time conductance is an unexplored competitive factor.

➢g_s of Pima cotton (*G. barbadense*) and common waterhemp (*A.rudis*) was determined by porometry in O_3 exposure chambers (4, 59 and 114 ppb, 12 hr mean) with irrigation [Well Watered (WW) and Water Deficit(WD)] as sub-effect. We hypothesize that O_3 increases nocturnal g_s and transpiration, as suggested in other species.

➢We found that increase in O_3 concentration and decrease in irrigation level both reduced day-time stomatal conductance ($P<0.05$) in cotton but not in common waterhemp. In contrast, increased O_3 levels increased night-time (2 AM) stomatal conductance in cotton but not in common waterhemp.

➢Simulations showed the net effect of O_3 in cotton was decreased transpiration, disproving the hypothesis. However, in common waterhemp, there was no effect of ozone and irrigation level in net transpiration.

➢Although nocturnal regulation of water loss was disrupted in cotton, the magnitude of night-time conductance was almost four-fold lower in cotton than in common waterhemp.

➢We conclude that reduced stomatal gas exchange (transpiration and photosynthesis) and reduced biomass productivity may shift crop-weed competition in favor of common waterhemp under elevated O_3. Nocturnal stomatal effects are not dominant in this system.

OBJECTIVE: The objective of this study was to evaluate the effects of O_3 and moisture on stomatal conductance and growth of a weed (common waterhemp) and an agronomic crop (cotton).

METHODOLOGY: A greenhouse experiment was conducted at the University of California, Kearney Agricultural Research and Extension Center, Parlier CA. Common waterhemp and Pima cotton were germinated and grown in a greenhouse.

At the 5-7 leaf stage (waterhemp) and first true leaf stage (cotton), seedlings were transferred to O_3 exposure chambers (Fig.1).

The experimental design was a split-plot with three replications and the experiment was conducted twice. The main- and sub- effects were O_3 exposure (4, 59, and 114 ppb; 12-hour mean) and irrigation level [(WW) and (WD], respectively.

Day-time stomatal conductance was measured on 9 days and night-time (2 AM) stomatal conductance on 7 nights, with a AP_4 leaf porometer, (Fig. 1).

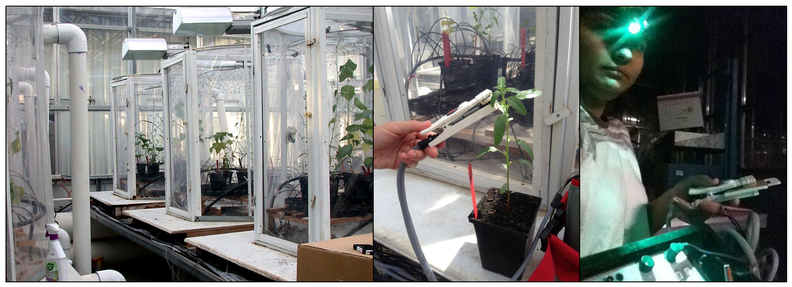

Fig. 1. Plants growing in the chambers (L), and day-time (C) and night-time (R) stomatal conductance measurements on the plants.

Night-time conductance was measured under low-intensity green ambient light to prevent perturbation of stomata. After 35 days of O_3 exposure, the above- and below-ground biomass of the plants were measured. Data were analyzed using GLM procedures in SAS.

RESULTS AND DISCUSSION: Stomatal conductance of cotton exhibited a typical bell-shaped diurnal timecourse, whereas stomatal conductance of common waterhemp declined throughout the day with lower maximum values. High O_3 concentration and decreased irrigation level reduced the day-time stomatal conductance of cotton but not that of common waterhemp . High O_3 increased night-time stomatal conductance in cotton but not in common waterhemp. This difference in conductance was almost four-fold.

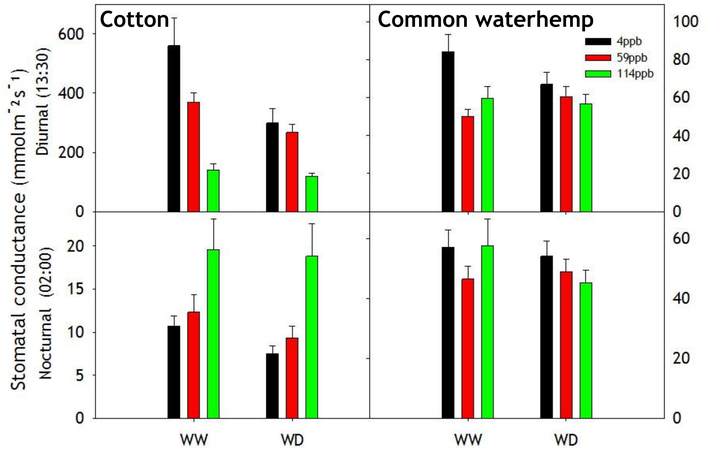

Fig.2. Responses of Stomatal conductance (gs) at representative diurnal (13.30) and Nocturnal (02:00) (± SE) in cotton (L) and common waterhemp (R) respectively.

Table 1.Impact of ozone and water deficit on calculated water consumption in the field by Pima cotton and common waterhemp.[1]

Time of Day	Species	Ozone Treatment	Water Treatment	Stomatal Conductance	Transpiration	Transpiration
		ppb		mmol m^{-2} s^{-1}	Mm hr^{-1}	Mm $month^{-1}$
02:00	Cotton	4	WW	10.7	0.055	
02:00	Cotton	114	WW	19.6	0.101	+8.2 in WW
02:00	Cotton	4	WD	7.5	0.038	
02:00	Cotton	114	WD	18.8	0.096	+10.4 in WD
02:00	Waterhemp	4	WW & WD	55.6	0.143	
02:00	Waterhemp	114	WW & WD	51.5	0.132	-1.9
13:30	Cotton	4	WW	560.3	5.75	
13:30	Cotton	114	WW	140.2	1.44	-388 in WW
13:30	Cotton	4	WD	298.4	3.06	
13:30	Cotton	114	WD	120.1	1.23	-165 in WD
13:30	Waterhemp	4	WW & WD	75.6	0.388	
13:30	Waterhemp	114	WW & WD	58.2	0.298	-8.0

[1]Source: Leaf Area Index (LAI=4) for cotton (Grantz et al.,1993), LAI=2 for common waterhemp (Nordby and Hartzler .,2004). Effect on transpiration is modeled as the difference between 114ppb and 4ppb O_3 , assuming 3 hours of average daytime transpiration and 6 hours of nocturnal transpiration per day for a 30 day month. Water treatments were combined for common waterhemp.

In cotton, nighttime (nocturnal) transpiration increased due to O_3, but this was small compared to the large reduction in daytime transpiration. O_3 reduced water use by cotton. Water deficit (WD) reduced total transpiration, causing the nocturnal effect of O_3 to be slightly larger, but the day time effect to be much lower.

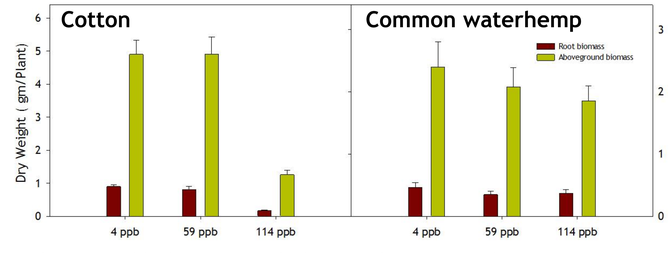

Fig. 3. Above- and below -ground dry weights (± SE) of cotton (L) and common waterhemp (R).

Above- and below-ground biomass was reduced by high O_3 in cotton but not in common waterhemp (Fig. 3).

CONCLUSION: High ground-level O_3 and water deficit may shift crop-weed competition in favor of certain problematic weed species such as common waterhemp. Both high night-time stomatal conductance in common waterhemp and disruption of stomatal regulation by O_3 could alter landscape water and carbon budgets.

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