Final Report on a 2007 Seed Money Grant from

The Center for Invasive Plant Management

Title

A physiological assessment of the effects of environmental changes on the invasiveness of kudzu, a noxious and highly invasive species

Investigator

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Proposal

Kudzu (*Pueraria montana*) is a highly invasive plant species distributed mostly in the southeastern U.S., but it was recently found in the northwestern states of Washington and Oregon. Kudzu may expand its territory eastward and southward from these two states and become a noxious weed in the northwest because of rising CO_2 in the atmosphere and the increased water use efficiency in plants grown at higher CO_2 levels. In this project, I examined the physiological traits in kudzu grown under future environmental conditions. The interactive effects of drought with CO_2 were concurrently studied in a growth chamber experiment. Results from this research will not only improve our understanding of environmental changes on the ecology of this exotic weedy species, but also contribute to more efficient control in the infested areas (e.g., eastern U.S.) and pro-active management in the areas where it is not yet a serious threat (e.g., northwestern U.S.). Data collected from this project are being used as preliminary data for more substantial funding.

Results and Discussion

Kudzu plants, which were propagated from different populations in Indiana were grown in two Conviron Growth Chambers (E-15) for the study. In one chamber, CO_2 concentration was maintained at 370 μmol mol^{-1} (ambient CO_2 treatment). In the other chamber, CO_2 concentration was maintained at 740 μmol mol^{-1} (elevated CO_2 treatment), which is the level projected for the end of this century. Within each chamber, two water regimes were established, well-watered and drought (half of the water as in the well-watered treatment). A study on the interactive effects of CO_2 and water will better our understanding of how kudzu will respond to a future environment, when CO_2 in the atmosphere will be higher and soils in some regions will be drier.

Photosynthetic rates were measured using an LI_COR 6400 Portable Photosynthesis System (Li-cor Inc., Lincolhn, Nebraska, U.S.). Elevated CO_2 significantly increased the net photosynthetic rate of kudzu plants (Figure 1), although no population difference was observed. These results are in general agreement with those from earlier studies on the response of kudzu to increasing CO_2 concentration in the atmosphere (Forseth and Teramura 1987a; Carter et al. 1989; Sasek and Strain 1989; Sasek and Strain 1990).

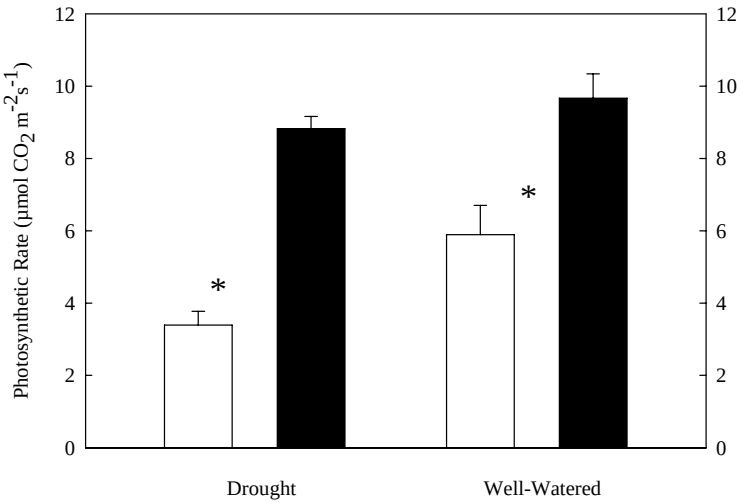

Figure 1. Average net photosynthetic rates of kudzu plants propagated from root crowns collected from populations in Chinook, Bedford and Patoka, Indiana. The plants were grown at ambient (open bars) or elevated (filled bars) CO_2 under two soil water conditions (drought and well-watered) in the growth chambers at IUPUI. n=4. * $P < 0.01$.

Leaf dark respiration (R_d) is an important component of the carbon budget of a plant, but little is known about effects of higher CO_2 on R_d of the extensive foliage of this invasive species. Leaf dark respiration rates were examined in detail in this CIPM-supported study. Plants grown under elevated CO_2 conditions had lower average dark respiration rates than the plants grown at ambient CO_2, but neither CO_2 level nor drought had statistically significant effect on leaf R_d (Figure 2). These numbers were also in the lower range of Rd for most herbaceous species. The results obtained in the study do not seem to support *Hypothesis 1* as outlined in the proposal, in which I hypothesized that kudzu would have a low R_d, regardless of CO_2 levels, and is therefore able to utilize the photosynthetically fixed carbon more efficiently than its native competitors.

The effects of elevated CO_2 and drought on leaf fluorescence (F_v/F_m), which indicates the degree of physiological stress, were also examined. While F_v/F_m varied slightly on different measuring days, no CO_2 or drought effect was observed (Figure 3). These fluorescence results suggest that kudzu plants showed no signs of physiological stress when grown under water-limited conditions. The lack of interactive effects between elevated CO_2 and drought indicates that kudzu plants will continue to do well when CO_2 concentration in the atmosphere is much higher than today's level, regardless of soil water conditions.

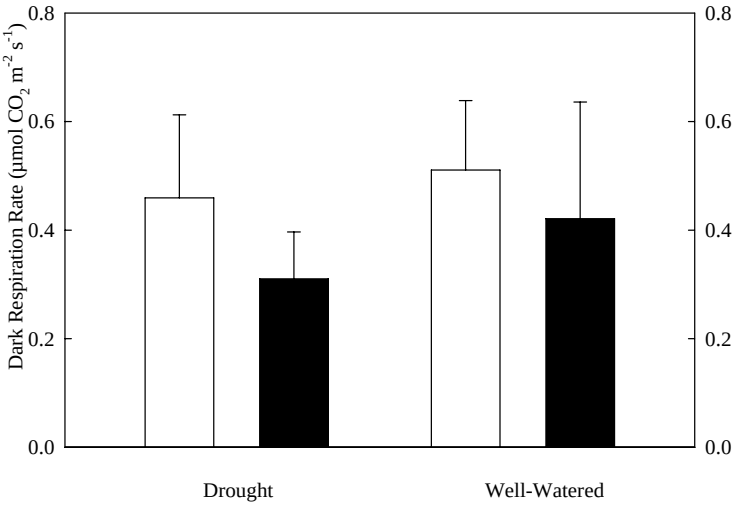

Figure 2. Dark respiration rate of kudzu plants propagated from roots collected from Chinook, Indiana. Plants were grown at ambient (open bars) or elevated (filled bars) CO_2 under two soil water conditions (drought and well-watered). n=2-4. Results from measurements on plants from the Bedford and Patoka populations are similar (data not shown).

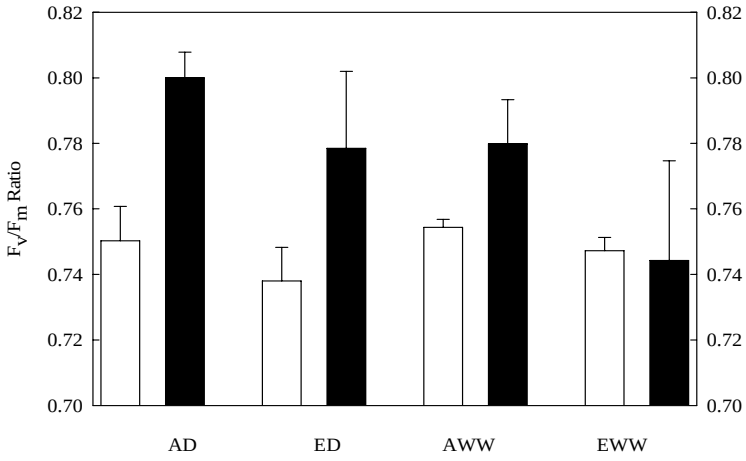

Figure 3. Average fluorescence measurement of kudzu plants propagated from root crowns collected from Chinook, Indiana. Plants were grown at ambient (A) or elevated (E) CO_2 levels and drought (D) and well-watered (WW) conditions on two different days (open and closed bars). n=4. Results from measurements on plants from the Bedford and Patoka populations are similar (data not shown).

It has been well-documented that the most important environmental factor that limits its distribution is low temperature (Forseth and Teramura 1987b). It has been long thought that kudzu is a tropical or sub-tropical weed and will not cause problems in regions where winter temperature is low. The spotting of kudzu in western states such as Washington and Oregon, as well as north Indiana, strongly suggests that there must be other mechanisms at play. It is currently not understood why it is so competitive against native species, even its photosynthetic and respiratory rates are comparable to the native species. A lot more needs to be done to better understand this highly invasive exotic species.

Benefits of the Seed Money

The CIPM grant enabled me to examine how the noxious invasive species of kudzu responded to simulated global environmental changes. The grant also supported field trips to two kudzu populations to compare a number of ecophysiological characteristics of kudzu and native species. The obtained results from the project were compared with other important weeds of the world (Reviewed in Wang and Mohan 2008). Although a large body of data was generated in this project, it seems I have more questions about kudzu than before the project started. These questions and data will be crucial for my next projects aimed at more detailed examining of high degree of invasiveness of this leguminous weed.

Publications

Wang, X.Z., and Mohan, J.E. 2008. Effects of global environmental changes on weeds. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources*. 2008 3, No. 067. (Preparation of this paper was supported in part by this CIPM grant, which was acknowledged near the end of the paper).

Ngigi, A.R. and Wang, X.Z. Ecophysiological responses of kudzu, *Pueraria montana*, to global environmental changes. In preparation for *Weed Science*.

Budget

	Amount used ($)
Undergraduate Support	953.99
Materials and Supplies	3,545.99
(fluorescent bulbs, incandescent bulbs,	
liquid CO2 gas, top soil, etc.)	
Indirect Cost	450.00
Total used	4,949.98

Literature Cited

Carter, G. A., A. H. Teramura, and I. N. Forseth. 1989. Photosynthesis in an open field for exotic versus native vines of the southeastern United States. *Canadian Journal of Botany* 67: 443-446.

Forseth, I. N., and A. H. Teramura. 1987a. Field photosynthesis, microclimate and water relations of an exotic temperate liana, *Pueraria lobata*, kudzu. *Oecologia* (Berlin) 71: 262-267.

Forseth, I. N., and A. H. Teramura. 1987b. Field photosynthesis, microclimate and water relations of an exotic temperate liana, *Pueraria lobata*, kudzu. *Oecologia* 71: 262-267.

Sasek, T. W., and B. Strain. 1989a. Effects of carbon dioxide enrichment on the expansion and size of kudzu leaves (*Pueraria lobata*) leaves. *Weed Science* 37: 23-28.

Sasek, T. W., and B. R. Strain. 1990. Implications of atmospheric CO_2 enrichment and climatic change for the geographical distribution of two introduced vines in the U.S.A. *Climate Change* 16: 31-51.

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