Effects of Elevated Atmospheric CO_2 on Tropical Spiderwort

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"The Tillage Lab" USDA Agricultural Research Service

ABSTRACT

Tropical spiderwort (*Commelina benghalensis* L.) is considered an invasive noxious weed and is becoming more of a problem in agricultural settings of the southeastern US. One neglected aspect of global change is the consideration of how invasive plants might react to the increasing CO_2 concentration in the atmosphere. This recently funded National Institute for Global Environmental Change (Southeast Regional Center) research project evaluates tropical spiderwort responses to CO_2 enrichment. Tropical spiderwort was grown under ambient and elevated levels of CO2. Under elevated CO2 conditions, plant organ parts exhibited significant increases in dry weight (leaf, 36%; flower, 30%; stem, 48%) and the overall increase in total aboveground biomass was 44%. Total stem length was unaffected by CO2 level while total leaf number and total flower number showed trends for increase (~20%) due to additional CO2. The strong growth response of tropical spiderwort suggest that its competitive ability with native plants will be enhanced in a future high CO2 environment.

INTRODUCTION

Invasive weeds are estimated to cost U.S. agricultural and forest producers 34 billion dollars each year from decreased productivity and increased weed control costs (Pimentel, 2002). One neglected aspect of global change is how invasive plants might react to the increasing atmospheric CO_2 concentration. Since elevated CO_2 stimulates photosynthesis (Amthor, 1995), resource use efficiency, and carbon allocation to belowground plant structures (Rogers et al., 1994), it may impact the competitiveness of invasive plants. Bright (1998) summarizes, "Fast-growing, highly invasive plants may also be able to profit directly from the atmosphere's increased carbon content...any slower-growing natives would tend to lose out to the invaders." We propose to investigate the effects of elevated CO_2 on growth, physiology, water relations, competitive ability, and control of invasive weed species detrimental to the Southeast economy.

GOALS and METHODS

In the first phase, tropical spiderwort will be assessed for its responses to increased CO_2. The second phase will consist of herbicide trials as affected by increased CO_2. Based on findings from the first and second phases, the third phase will be a series of competition studies conducted under elevated CO_2 conditions.

Plants will be exposed to CO_2 using an open top chamber system (Rogers et al., 1983) located at the soil bin facilities at the USDA-ARS National Soil Dynamics Laboratory, Auburn, Alabama. Greenhouse established seedlings will be transplanted into large plastic containers, using standard potting media, prior to CO_2 exposure. Soil fertility will be reflective of southeastern U.S. conditions. Containers will be subjected to ambient rainfall and watered to prevent drought-induced plant mortality. Two levels of CO_2 (ambient and twice ambient) will be maintained in a randomized complete block design (6 replications).

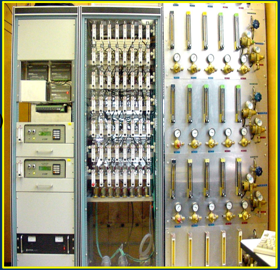
During the course of each phase, plant photosynthesis (net C assimilation) will be measured weekly for each species using a Li-Cor 6400 portable gas exchange system; conductance and transpiration are concomitantly determined while water use efficiency can be calculated from these data. At the end of each phase, plants will be separated into organ parts (i.e., leaves, stems, roots). Using standard practices, other aboveground parameters will be assessed (e.g., leaf area, stem number, height, diameter, and numbers of nodes, branches, and leaves). Roots will be separated from soil using the sieve method. Plant organs will be dried (55 °C) and dry weights recorded. Organ parts will be ground (0.2 mm sieve) and analyzed for total C and N with a LECO CN-2000 analyzer; C and N partitioning will be calculated. Carbon and nitrogen content of soils will also be determined. Statistical analysis of all data will be done using the Mixed procedure from SAS (Littell et al., 1996).

Outdoor soil bin facilities (right side) equipped with CO_2 exposure chambers located at the USDA-ARS National Soil Dynamics Laboratory in Auburn, AL.

CO_2 Exposure System

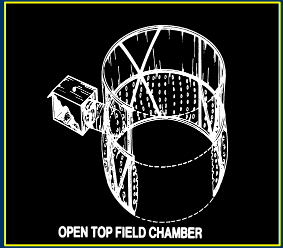
CO_2 Dispensing & Monitoring →

← Open Top Chamber (OTC)



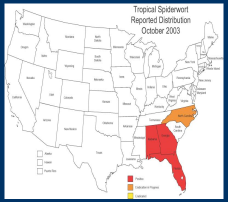
OTC Schematic Drawing ↓

CO_2 exposure 24 hours day^{-1}



CO_2 Treatments:
- ✓Ambient
- ✓Twice Ambient

Photographer, Andrew Price, USDA-ARS-NSDL



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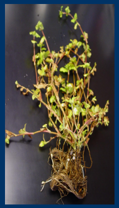

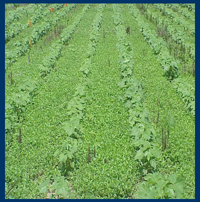

Photographer, Stanley Culpepper, The University of Georgia

HYPOTHESES and RESEARCH GOALS

The three major hypotheses to be tested are: *Hypothesis 1:* Elevated atmospheric CO_2 will result in positive growth responses of tropical spiderwort. *Hypothesis 2:* Herbicide tolerance of tropical spiderwort will increase with CO_2 enrichment, requiring increased application rates; tolerance will vary among ecotypes collected from across the Southeast; and *Hypothesis 3:* Competition from tropical spiderwort will reduce growth and yield of crops. Effects of elevated CO_2 on this competitive interaction will depend on physiological characteristics of both the crop and tropical spiderwort; however, growth in monocultures will not be a reliable predictor of response under competitive conditions. Further, while competition will not affect total biomass production, it will impact carbon dynamics by altering allocation among species.

The first phase will address *Hypothesis 1*. Tropical spiderwort responses to CO_2 level will be assessed.

The second phase will address *Hypothesis 2* using herbicide trials. Plants will be treated (herbicides to be determined) at the twice the highest labeled rate, as well as full, one-half, and one-quarter of the highest labeled rate. Efficacy will be visually rated on a zero (no effect) to 100 (complete effect) and re-growth will be measured. Efficacy will be compared to a non-treated check for each CO_2 level.

Based on the previous two phases findings, the third phase (*Hypothesis 3*) will be a series of competition studies which may use the following pairs: (1) tropical spiderwort (C_4) with evergreen conifers (C_3) - e.g., loblolly pine (*Pinus taeda*); (2) tropical spiderwort with agricultural crops - e.g., cotton (*Gossypium hirsutum* L, C_3), soybean [*Glycine max* (L.) Merr.; C_3 N_2-fixer], and grain sorghum [*Sorghum bicolor* (L.) Moench; C_4 grass]; and (3) tropical spiderwort and the pasture species bahiagrass (*Paspalum notatum* Fluegge; C_4 grass). These combinations represent problems commonly encountered by Southeastern producers and represent species which differ in lifeform, growth habit, and physiology.

Invasive plant pests have the capacity to disrupt terrestrial ecosystems; nowhere is this threat greater than in the southeastern U.S., with its numerous ports of entry and mild climate. This research project will generate information to help combat invasive plants in a future CO_2-enriched world.

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