INTRODUCTION

SPUDSIM incorporates similar phenological and carbon allocation routines as in SIMPLO (Fugle, 1992). The model is integrated with a modified version of the algorithms (Hodges, 1996) to simulate water, solute, heat and gas movement. Root growth is simulated using a diffusion scheme in horizontal and vertical directions. Climate, soil status, management and genetic information is processed by the model which simulates plant water uptake, nitrogen and water status, plant production, leaf and canopy water exchange, dry matter production and carbon allocation. Outputs include hourly predictions for air dry weight, root and leaf water contents, net photosynthesis, transpiration, and respiration. Outputs are hourly for the entire simulation period. In the current version, leaf growth and leaf water potentials are not outputted.

EXPERIMENTAL DATA

Simulations conducted in 12 Soil-Plant-Atmosphere Research (SPAR) chambers located at USDA-ARS facilities in Beltsville, Maryland. 34 chambers (Fig. 4) provided precise control and monitoring of T, CO₂, RH, and irrigation. Whole plant net carbon exchange rates were calculated at 30 sec intervals and respiration rates at 15 min intervals over the course of the study. Each chamber has a 1 m² plant production area and 1 m² irrigation is provided via a micro-fertigation system and water content monitored using TDR-probes.

SPUDSIM v. 1.1

SPUDSIM simulates all variables used in the research, except for 

RESULTS

DAILY GAS EXCHANGE

An example of daily canopy net photosynthetic and respiration rates is shown for the 75% CO₂ treatment for both CO₂ levels (Fig. 4). Slope values and their corresponding R² values for all the CO₂ treatments (Table 3) and transpiration (Table 4) followed the same pattern as observed for the net photosynthetic rate. Leaf gas exchange rates in all treatments, when compared to the control, showed increased values at 75% CO₂ (Fig. 5). The slopes values were calculated using a best-fit line for all data sets, the model tended to over-response to soil water status, particularly towards the middle and end of the season when the soil water content is depleted.

SIMULATION PROTOCOLS

(1) **SPUDSIM** was calibrated on the ambient CO₂, 100% irrigation. No other modifications or calibrations were applied for any of the other 11 model runs.

(2) **Inputs** for each model run (i.e. one simulation per chamber) used the uniquely measured environmental, irrigation data, and specific harvest data associated with each chamber.

(3) **Nitrogen** was added as solid amendment and in liquid fertilizer and was thus a confounding factor. The ability to simulate nitrogen stress (or excess) was therefore included in all model runs.

**Drought Effects**

Observed and simulated end-of-season dry matter is shown for ambient (left) and elevated (right) CO₂ model runs (Fig. 5). Model predictions were within two standard errors for all chambers. However, simulated carbon allocation among leaves and above and below ground organs did not always correspond to observed relationships. For example, experimental results reflected the higher photosynthesis of CO₂ to the extent that dry matter was increased, particularly for elevated CO₂ (Table 3). Below ground dry matter allocation was not predicted to H₂O, but not the observed effect (Table 2).

**Leaf Water Use Efficiency (WUE)**

In the observed and modeled case, elevated CO₂ plants did not always use leaf water (Table 4), but due to higher biomass production, the WUE was usually higher as compared to the corresponding controls. Therefore, WUE was simulated to be higher in elevated CO₂. Simulated WUE followed expected trends, increasing with drought and CO₂ concentration (Table 5).

**DISCUSSION**

Using just a single calibration point, the SPUDSIM model was able to realistically respond to a wide range of irrigation treatments at two different CO₂ levels with respect to total dry matter production and assimilation rates, and leaf water potential. The model predicts that decreased stomatal conductance to CO₂ results in an increase in leaf water potential to the extent that C₃ plants can respond, and this increase in leaf water potential is reflected in increased photosynthesis and growth. These shifts in preference for CO₂ can be modeled in a mechanistic fashion. Overall, these results imply that SPUDSIM can accurately respond to future CO₂ and drought scenarios.

**REFERENCES**


Hodges, K.A. 1996. A design for a modular, generic soil simulator to interface with plant models. 1996. A design for a modular, generic soil simulator to interface with plant models. Planta 198, 1


TIMELINE:...