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NITROGEN AND CARBON DIOXIDE INTERACTION ON COTTON GROWTH AND DEVELOPMENT

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Abstract

The carbon dioxide concentrations ([CO_2]) of earth's atmosphere have increased from about 185-275 to current 375 ppm since 1750 and may reach up to 600-1000 ppm by end of this century, largely due to burning of fossil fuels. It is not clear as to how crops respond to the other environmental factors such as nutritional aspects in the future environment while experiencing elevated [CO_2] conditions in their canopies. There is not yet any clear consensus regarding the magnitude and nature of interactions between elevated [CO_2] and nutrient availability for crop growth. So, the objectives of our experiment were (1) to understand how the leaf N concentrations are altered by [CO_2] and nitrogen (N) treatments and (2) to evaluate the sensitivity of cotton growth and reproductive responses to [CO_2] and N nutrition.

The effects of CO_2 and N on cotton growth and development were investigated by growing cotton cultivar NuCOTTN 33B plants in sunlit, controlled environment chambers at 180 (subambient), 360 (ambient) and 720 μmol mol^{-1} (elevated) [CO_2]. The plants were exposed to different [CO_2] immediately after seed germination. Two levels of nitrogen (N) treatments (N sufficient and N deficient) were initiated from flowering. Changes in leaf N concentrations, plant height, mainstem nodes, branching pattern, boll and boll-component parameters, and photosynthesis were investigated.

Elevated [CO_2] reduced the leaf N concentrations during boll development period by 16% under N sufficient and 42% under N deficient conditions when compared to subambient [CO_2]. Nitrogen deficiency reduced the leaf N concentrations by 39% under elevated, 29% under ambient and 11% under subambient [CO_2] conditions. Elevated [CO_2] significantly increased mainstem lengths (21%) and node numbers (20%) compared to subambient [CO_2] conditions. Significant [CO_2] $\times$ N interactions were detected for vegetative and fruiting branch numbers, total bolls produced and retained suggesting that the response of [CO_2] is strongly N dependant. In general, plants grown in elevated [CO_2] with sufficient N produced more vegetative and fruiting branch numbers, produced and retained more bolls and consequently more biomass compared to all other treatments. Enriching [CO_2] at N deficient conditions compensated the depression of cotton growth that occurred at N deficient plus ambient [CO_2] conditions, indicating that changes in fertilizer management may be required under changing [CO_2] in the future.

Our results also have implications for management of N fertilization. The reductions in leaf N concentrations with doubling of atmospheric [CO_2] suggest that current critical N values, which were established when [CO_2] was considerably lower (330 μmol mol^{-1}) than the present levels, requires reassessment as atmospheric [CO_2] is steadily increasing. The mineral requirements of plants grown in high [CO_2] environments and predicting nutrient requirements of plants in such environment may be more complicated than expected. Careful attention to N fertilizations will be necessary to take the full benefit of any future increases in atmospheric [CO_2].