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INFLUENCE OF ULTRAVIOLET (UV-B) RADIATION AND ELEVATED CO_2 ON LEAF REFLECTANCE PROPERTIES OF COTTON (*Gossypium hirsutum*)

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Abstract

Climate models predict continued depletion of stratospheric ozone until about 2050, even if the Montreal Protocol is fully implemented. The ozone depletion is likely to result in a 6-7% increase in troposheric (or near Earth) UV-B radiation. Along with ozone depletion, it is predicted that the present CO_2 concentration (360 – 380 µL L^{-1}) would double by 2050 due to anthropogenic causes, an increase that is known to enhance crop production by 33%. The objectives of this study were to identify pigment and spectral reflectance changes of cotton leaves due to UV-B radiation and ameliorative effects of elevated CO_2 on UV-B effects.

A naturally lit controlled environment study using the Soil-Plant-Atmosphere-Research (SPAR) facility on the North Farm of Mississippi State University, Mississippi State, MS, was conducted. An upland cotton cultivar, Nucot 33B, sown on 1 August 2001 in 1 m deep sand-filled soil bins of the SPAR units. Treatments imposed were two levels of CO_2 (360 and 720 µL L^{-1}) from sowing, and three levels of UV-B - 0 (No-UV-B), 8 and 16 kJ m^{-2} d^{-1} from 10 days after emergence (DAE). The Plexiglas chambers of the SPAR units are opaque to solar UV radiation. Ultraviolet-B radiation treatments were imposed by arranging a rack of 8 UV-313 fluorescent bulbs at a height of 0.5 m from the top of the canopy and intensity was controlled by using 40W dimming ballasts. The bulbs were covered with di-acetate film to filter UV-C radiation, and were changed at 3 d intervals. The UV-B radiation received at the top of the canopy was measured daily with a radiometer. Leaf cholorophyll (*a* and *b*), total carotenoid and total phenolic concentrations were estimated by measuring absorbance of leaf extracts using an UV/Visible spectrophotometer, at weekly intervals, from 20 DAE. Immediately prior to pigment sampling and while leaves were still attached to the plants, spectral reflectance between 350 and 2500 nm (2 -5 nm resolution) was measured on the same leaves using an ASD FieldSpec FR Spectroradiometer.

Exposure to UV-B treatments (8 and 16 kJ) decreased total chlorophyll and carotenoid concentrations in cotton leaves, irrespective of the CO_2 concentration. Only Chlorophyll *a* concentration was higher by 25% in elevated CO_2 treatment compared to ambient CO_2 with both receiving 0 kJ UV-B. No interaction between UV-B and CO_2 was recorded for Chlorophyll *b* and carotenoid concentration. An increase in UV-B caused cotton leaves to accumulate more of total phenolics with a greater increase at 8 kJ than at 16 kJ of UV-B. At 8 kJ of UV-B, total phenolics increased by 9% in 360 and 30% in 720 µL L^{-1} CO2 treatments. In the leaves exposed to 16 kJ UV-B, 720 µL L^{-1} CO_2 treatment resulted in a slight increase of phenolics (2%) compared to the control, while in the 360 µL L^{-1} CO_2 treatment, a decrease of 16% of total phenolics was recorded. Disruption of the pathways synthesizing phenolics could be the reason for lower accumulation of phenolics at high UV-B (16 kJ).

Spectral reflectance of cotton leaves was higher when exposed to UV-B radiation and elevated CO_2 (760 CO_2) compared to the control treatment (0 kJ UV-B and 360 CO_2). Single band spectral reflectance values and reflectance ratios were correlated with pigment concentration. Cotton chlorophyll *a* concentration was highly correlated (r^2 = 0.65) with the spectral ratio of 677/749 nm. Phenolics did not correlate with the spectral bands as their reflectance lies below the lowest waveband (350 nm) the spectroradiometer could measure. The effects of different UV-B radiation doses on loss of chlorophyll and carotenoid pigments and on increased total phenolics of cotton leaves was not ameliorated (or mitigated) by elevated CO_2. Further analysis of the data is required to identify UV-B-specific wavebands in the leaf reflectance spectra.