INTERACTIVE EFFECTS OF OZONE, CARBON DIOXIDE, AND SOIL NITROGEN ON COTTON FIBER PROPERTIES.

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Abstract

Pot-grown Deltapine 51 cotton plants were exposed to three levels of ozone [24, 51, or 78 nL L^{-1}], carbon dioxide [ambient, +175 μL L^{-1} or +350 μL L^{-1}], and soil nitrogen [0.2, 0.4, or 0.6 g urea-formaldehyde N per liter of soil mix, pH 6.4] in North Carolina State University open-top field chambers [volume = 17 m^3]. The 51 nL L^{-1} ozone level approximated ambient ozone levels during 1996 in Raleigh, NC. The lowest ozone concentration was achieved through charcoal filtration of the air input. Ozone and carbon dioxide additions were made from 11 to 134 days after planting in 1995 and from 9 to 115 days after planting in 1996 when the experiment was terminated by Hurricane Fran.

Analyses of AFIS-generated fiber-property data from the completely randomized factorial design [with split plots and nitrogen level as the subunit] indicated significant first-order effects of all three environmental factors on fiber length, diameter, and cross-sectional area. When two experimental factors were held constant as the third factor was increased, fiber length increased as ozone level increased and decreased as carbon dioxide level was raised. Increasing soil nitrogen also increased fiber length, nitrogen related fiber length increases were smaller than those related to increasing ozone concentration.

Increasing carbon dioxide levels decreased fiber length except at the lowest level of soil nitrogen. Increased ozone levels increased fiber length except at the lowest soil nitrogen level. When the carbon dioxide concentration was raised above the ambient level, the ozone-related increase in fiber length did not occur. Increased ozone also resulted in decreased Short Fiber Content, and that ozone effect also disappeared when carbon dioxide concentration was raised above the ambient level.

The main effects of the ozone, carbon dioxide and soil nitrogen concentrations were also highly significant in determining fiber diameter. The negative effect on fiber diameter of increasing ozone level was much greater than the effects of increasing either carbon dioxide or soil nitrogen. At ambient levels of carbon dioxide, increased ozone concentration resulted in decreased fiber diameter. When soil nitrogen and ozone levels were held constant, increased levels of carbon dioxide had no significant effect on fiber diameter. However, increasing carbon dioxide concentration above the ambient level eliminated the ozone-related decrease in fiber diameter. The interaction of increased ozone and increased carbon dioxide was the 'mirror image' of the changes in fiber length due to interaction of the two atmospheric components.

Increased ozone also elicited a marked decrease in fiber cross-sectional area. The highest levels of ozone and carbon dioxide interacted to reduce the cross- sectional areas of chronologically mature fibers to levels reported for immature fibers [112 μm^{-2} with an Immature Fiber Fraction of 13.5% and a micronAFIS of 3.83]. Increased ozone levels decreased fiber cross-sectional area at all soil nitrogen levels.

The main effects of the three treatments were highly significant factors in fiber maturity measured as Immature Fiber Fraction [IFF] by AFIS. Increasing levels of all three treatments decreased fiber maturity to similar degrees. Increases in the carbon dioxide level increased IFF percent. Increased ozone also increased IFF, particularly when the ozone concentration was twice the ambient level. Increasing soil-nitrogen level increased IFF when carbon dioxide was increased to 1.5 times the ambient level, but this effect on fiber maturity disappeared when the carbon dioxide concentration was twice the ambient level. The concentrations of ozone, carbon dioxide, and soil nitrogen were also important factors in fiber micronaire [measured as micronAFIS]. Increases in the levels of the three treatments decreased micronaire.

The treatment effects and interactions among the treatments were most clearly defined in the fiber length, diameter, and cross-sectional area data. The increases in IFF percent and the decreases in the maturity component of micronaire were less easily defined relative to the treatments, and there was no clear ozone X carbon dioxide interaction with respect to fiber maturity. Comparison of the micronaire data from 1995 and 1996 suggested that the early termination of the 1996 crop may have been a factor in the reduction of fiber micronaire at the highest ozone level. There was no ozone effect on the 1996 micronaire at the lowest ozone concentration, and the longer growing season in 1995 reduced the ozone effect on micronaire in that year. Interpretation of the interactions of ozone and soil nitrogen must include the possibility that the highest level of ozone accelerated the release of soil nitrogen, a phenomenon observed when soils high in organic matter [litter] are exposed to air pollutants such as ozone.

The addition of ozone to ambient levels of carbon dioxide resulted in significant increases in fiber length accompanied by 'mirror image' decreases in fiber diameter and cross-sectional area. These effects of elevated ozone were not

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observed when the carbon dioxide concentration was increased above ambient level. The ozone effects were most evident when the soil nitrogen levels were lowest. Significant second-order and third-order interactions were noted among the fiber-property effects of soil nitrogen, ozone, and carbon dioxide levels. Increases in the three treatment factors negatively affected fiber maturity and, to a lesser extent, micronaire.

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