SIMULATING THE EFFECTS OF CLIMATE CHANGE ON COTTON PRODUCTION IN THE US MIDSOUTH

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Abstract

Cotton crops in the future will be subjected to weather conditions for which they were not bred. Currently, atmospheric carbon dioxide concentration is about 360 ppm, and there is general agreement among climatic and atmospheric scientists that the atmospheric carbon dioxide concentration could range from 510 to 760 ppm some time in the middle or latter part of the 21st century. Global circulation models predict that increased concentrations of carbon dioxide and other radiative gases would cause warming of the earth's surface and other weather changes. Since cotton growth and yield are controlled by weather, it behooves us to understand the implications of such weather changes on agriculture.

Changes in the climate on a global scale should impact local agriculture and therefore global economy. Predicting the future course of cotton production in a changing climate is confounded by the complexity of the agricultural systems, and of socioeconomic systems governing fiber supply and demand. A mechanistic crop model that can predict crop responses to existing growing conditions is needed. The model should include crop responses to a wide range of environmental conditions including extreme conditions.

We used a physiologically-sound cotton simulation model, GOSSYM, to study the impacts of climate change on cotton production in the US Midsouth. Climate data generated by Dr. Mearns (RegCMs, National Center for Atmospheric Research, Boulder, CO, personal communication) were used as inputs for the model. Projected monthly mean temperatures (maximum and minimum) and ratios for precipitation, solar radiation and wind speed generated by RegCMs (Global circulation model down scaled to predict local conditions) were used to create 30-year weather scenarios for Stoneville, MS (latitude 34º) by adding the monthly mean temperatures and multiplying the ratios for the other three parameters to the actual daily values of the weather data from 1964 to 1993. This methodology provided us daily future weather information for 30 years, as required for input to the cotton model. This methodology provided, at least, the existing natural variability in weather which is important because critical crop responses to environmental conditions are on a short-time basis. Using the modified weather as inputs, cotton yields and developmental events were estimated.

Changes projected in the climate have drastic effects on cotton production in the Midsouth. The fertilization effect of elevated atmospheric carbon dioxide concentration (660 ppm) resulted in 43% increase in yield over the current conditions. When all other climatic changes were included as inputs in simulations, there was only 6% increase in the yield. Growing season was shortened by 10 days in the future climate. Among the climatic variables, changes in projected temperature and rainfall adversely affected cotton yields. Management strategies such as changing planting dates may ameliorate some of the negative impacts of climate change. Also, a 40% increase in rainfall over the predicted resulted in a 15% increase in yield, suggesting that irrigation may partially mitigate the adverse effects of the climate in the Midsouth region. A major adaptive response will be breeding heat-and-cold and drought resistance cotton varieties that may be better adapted to a new climate.

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