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CLIMATE CHANGE AND US COTTON PRODUCTION: GROWTH AND YIELD

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Abstract

Production agriculture will be greatly affected by the changes projected in weather and concentrations of atmospheric carbon dioxide[CO_2] in the coming decades. The objective of this investigation was to study the impact of projected weather and [CO_2] changes on cotton growth and yield. The cotton simulation model, GOSSYM, was updated to include functional algorithms developed from experimental studies on cotton responses to a changing environment. These data include the effects of temperature (including extremes), water and nutrient stresses on many physiological processes, and yield. A new generic CO_2-sensitive photosynthesis model, a high-temperature injury on fruiting structure sub-model, an improved phenology and growth models were added into GOSSYM to accurately predict climatic change effects on cotton growth and development. GOSSYM was then used to compare yield trends using historical (7-35 years) and projected weather data, which were the historical data modified using the projections derived from the nested regional climate model (RegCMs) of the National Center for Atmospheric Research in Boulder, CO. GOSSYM runs were made in seven locations: 1) Florence, SC, 2) Meridianville, AL, 3) Stoneville, MS, 4) Lubbock, TX, 5) Artesia, NM, 6) Portageville, MO and 7) Corpus Christi, TX using common agricultural inputs and each site's respective soil, historical and future weather. The common agricultural inputs consist of the following: a) growing season from May 1 to October 31 for a total of 184 growing days, b) row spacing of 38 in. and a plant population of 41,267 plants ac^{-1}, c) pre-plant fertilizer application of 150 lb ac^{-1} of nitrogen and d) rain-fed conditions. In general, GOSSYM's yield predictions varied from location to location depending on the climate and the soil type. It responded to temperature changes as expected–as temperature rises, cotton exhibited rapid growth and development. With higher temperatures, all growth and developmental processes were hastened; thus the appearances of each of the developmental events occurred earlier under the projected climate scenarios. The downside of these temperature effects was shorter plants reflecting greater water deficits at the higher temperatures in the future climates. Plant height is a major determinant of light interception; i.e., shorter plants translate to reduced photosynthesis. Even with the projected increased [CO_2], greater fruit abscission resulted from water, heat or carbon stresses or a combination of these stress factors. Yield declines ranged from 3% in Portageville, MO to 37% in Lubbock, TX. In Corpus Christi, TX, a 4% increase in yield was simulated in the future climate primarily because of historically high rainfall, unchanged rainfall projections and a modest increase in average temperature of 3°C during the growing season in the future climates. The yield reduction in Lubbock, TX in the future climate was because of a combination of projected temperature increases and low precipitation amounts, especially during the boll-filling period projected in the future climates. Since the soil is 70% sand, it will require irrigation to offset the effect of low rainfall on yield in that area. The projected higher temperatures and drop in rainfall, or a combination of the two, resulted in extended drought periods and increased fruit abscission resulting in lower yield in the future climatic conditions. Additional irrigation and changes in planting date can help alleviate the nutritional stress problems brought about by reduced rainfall and high temperatures. These crop-soil-weather interactions are all very dependent on timing and degree of environmental stresses, which will determine the extent of injury imposed on the crop.