Machine Learning for Bioenergy Sorghum Yield Prediction under Future Climate Scenarios

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Crop yield modeling has the potential to play an important role in the design of national strategies for agricultural production, particularly under a changing climate. The application of predictive techniques in agriculture has historically focused on food crops; however, in the emerging bioeconomy, forecasting yields of bioenergy crops at fine spatial resolutions has grown increasingly useful to the evaluation of near and long term pathways to scaling up biofuel production. Understanding how bioenergy crops targeted for cellulosic fuel production such as sorghum will perform under future climate scenario is especially crucial as the future emission scenarios indicate higher severity droughts and temperature extremes in the continental USA. In order to inform the genetic engineering of bioenergy crops to withstand these challenges, robust modeling techniques are needed to provide spatially-explicit predictions and insights on how crop performance will respond to changing environmental conditions. We present a comparative analysis of several modeling approaches for predicting yields of biomass sorghum at the county level in the US based on historical data. Validation of candidate models revealed that Extra Randomized Trees (ERT) regression, a variant of the Random Forest machine learning algorithm, outperformed a myriad of linear models which included stepwise, least absolute shrinkage and selection operator, Ridge and Geographically Weighted regression. Incorporating future climate projections from an ensemble of Global Circulation Models, we demonstrate the use of our ERT model to predict sorghum yields in 2020, 2050, 2080, and 2099 across four Representative Concentration Pathway (RCP) scenarios of the Intergovernmental Panel on Climate Change. Our predictions indicate a slight decreasing trend of sorghum yields over these future years, with greater decline in more severe RCP scenarios.