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Simulating the Growth Dynamics of Afforestation Species under Climate Change Impacts in Northern Benin

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Abstract

(Re-)Afforestation efforts, to be a sustainable solution option for combating land degradation in West Africa, have to account for projected changes in climatic conditions such as increased temperature and rainfall variability. We applied field data from an afforestation experiment in the Sudano-Sahelian zone of West Africa to agroforestry model WaNuLCAS for predicting the growth and biomass production of two woody species (*Jatropha curcas* L. and *Leucaena leucocephala* Lam.), as a first step to the assessment of the impacts of climate change on their growth. Data for model calibration and validation stemmed from the field experiment conducted over 2014 and 2015 rainy seasons and the intervening dry season. The tree species were subjected to four experimental treatments: (1) a control treatment (e.g. neither irrigation nor fertilisation), (2) irrigation, (3) fertilisation and (4) a combination of irrigation and fertilisation. The model was calibrated with the 2-year dataset from the control treatment and validated against the datasets from the other treatments. The seasonal dynamics of stem diameter, height, and aboveground biomass (AGB) were reasonably well reproduced by the model ($R^2 > 0.5$; RMSE ca 6–30%). The poor reproducibility of the biomass loss due to litterfall in the dry season resulted in a poor fit between observed and simulated AGB values for both species (RMSE >20%). The overall simulation results were satisfactory, based on the values of the coefficient of determination (CD) between 0.5–2, model efficiency (EF) and coefficient of residual mass (CRM) which were closer to 1 and 0, respectively. These findings provide a basis for (i) predicting climate change impacts on tree growth and productivity, (ii) identifying growth-limiting factors under future climatic conditions and (iii) exploring silvicultural options for sustainable (re)afforestation efforts in the region.

Keywords: Climate change, land degradation, Silvicultural management, WaNuLCAS model, West Africa