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Modelling crop yield, soil organic C and P under variable long-term fertilizer management in China

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Phosphorus (P) is a major limiting nutrient for plant growth. P, as a nonrenewable resource and the controlling factor of aquatic entrophication, is critical for food security and human future, and concerns sustainable resource use and environmental impacts. It is thus essential to find an integrated and effective approach to optimize phosphorus fertilizer application in the agro-ecosystem while maintaining crop yield and minimizing environmental risk. Crop P models have been used to simulate plant-soil interactions but are rarely validated with scattered long-term fertilizer control field experiments. We employed a process-based model named Environmental Policy Integrated Climate model (EPIC) to simulate grain yield, soil organic carbon (SOC) and soil available P based upon 8 field experiments in China with 11 years dataset, representing the typical Chinese soil types and agro-ecosystems of different regions. 4 treatments, including N, P, and K fertilizer (NPK), no fertilizer (CK), N and K fertilizer (NK) and N, P, K and manure (NPKM) were measured and modelled. A series of sensitivity tests were conducted to analyze the sensitivity of grain yields and soil available P to sequential fertilizer rates in typical humid, normal and drought years. Our results indicated that the EPIC model showed a significant agreement for simulating grain yields with R2=0.72, index of agreement (d)=0.87, modeling efficiency (EF)=0.68, $p<0.01$ and SOC with R2=0.70, d=0.86, EF=0.59, and $p<0.01$. EPIC can well simulate soil available P moderately and capture the temporal changes in soil P reservoirs. Both of Crop yields and soil available were found more sensitive to the fertilizer P rates in humid than drought year and soil available P is closely linked to concentrated rainfall. This study concludes that EPIC model has great potential to simulate the P cycle in croplands in China and can explore the optimum management practices.