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Pathway of soil improvement through straw return to promote yield increase cannot be ignored

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Abstract: As a source of fresh soil organic carbon (SOC) input, straw return contributes to yield increase not only through direct effects such as nutrient input from straw and increasing SOC, but also indirectly promotes crop yield increase via gradual soil improvement processes over long-term implementation. However, current major crop models fail to capture the gradual changes in soil properties driven by SOC, which limits the accurate assessment of crop yield and soil processes under straw return. In this study, we modified the soil module of APSIM by integrating mathematical models, evaluated the overall regional benefits of straw return implementation and its mediated soil improvement effects, and quantified the contributions of both the direct effects of straw return and the soil improvement pro-cesses to yield increase. The results showed that under straw return, the original APSIM model overestimated the total evapotranspiration during the growing period and soil bulk density, while underestimating SOC, soil field capacity, and maize yield. An opposite pattern was observed under non-straw return conditions. The yield increases induced by straw return in the historical period were 0.48 t ha^{-1} and 1.28 t ha^{-1} in China northeast (NEC) and northwest (NWC) planting regions, respectively, and such yield increases would further expand under future climates. In NEC, the direct impact pathway of straw return contributed more to yield increase (with contributions ranging from 60% to 70%), where-as in NWC, the gradual soil improvement induced by straw return made greater contribution to yield increase (about 60%). The analysis of driving factors for yield increase indicated that changes in straw nitrogen content were the most important driving factor affecting yield increase. In NWC, yield increase also strongly responded to changes in SOC and field capacity, and many driving factors exhibited the thresholds for achieving the maximum yield increase under straw return. Our study provides an important supplement to the current regional-scale agricultural production system simulation, emphasizes the critical role of long-term soil dynamic changes in model optimization, and suggests promoting the straw return policy which conducing soil improvement, thereby providing technical support for regional and even national food security.

Keywords: *Straw return, soil improvement, yield increase contribution, APSIM*