Soil with high plant available water capacity can mitigate the agricultural drought effects on wheat biomass dynamic change

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Abstract: Drought is a complex natural phenomenon, which can result in various negative effects on the natural environment or human society, such as reducing crop yield. Australia is one of the world's top cereal production exporters, and the wheat belt of New South Wales (NSW) is the most important crop area that accounts for most of the national wheat production. Previous studies have analysed the impacts of drought on wheat yields in Australia. They found that the wheat yield reduction was primarily due to the drought caused by climate variability, as wheat is mainly grown under rainfed conditions in this region (Rahmati et al., 2020). It has been proved that soil plays a crucial role in buffering the negative effects of drought on crop yield (Wang et al., 2017). Healthy, well-structured soils have the ability to retain moisture and provide a suitable environment for plant roots to access water even during dry periods.

In this study, we combined the Agricultural Production System sIMulator (APSIM) crop model simulation and copula functions to quantify the impacts of agricultural droughts on the loss risk probability during the main growth stages of wheat in the NSW wheat belt. We selected six sites as representatives of major climatic characteristics (e.g., dry hot, wet cool) in the wheat belt, and 12 soils with different plant available water capacity (PAWC) to compare the soil buffer effects on wheat growth under drought conditions. We used APSIM to simulate wheat phenology, daily biomass, and soil water content (SWC). Then the standardized soil moisture index (SSI) was calculated based on SWC to represent the water deficit. The correlation coefficients between daily biomass change (Δbiomass) and SSI during four main growth stages of wheat were calculated, including end of juvenile (EJ), floral initial (FI), flowering (F), and start grain fill (GF) for six sites. Finally, we estimated the loss risk of Δbiomass under different drought severities using condition probability.

The results showed that the simulated Δbiomass and yield of wheat increased with the increase of PAWC. The simulated Δbiomass and yield in western sites were lower than that in eastern sites. The highest correlation coefficients were found during FI for each soil across all six study sites. The loss risks of Δbiomass during FI under certain drought conditions were decreased with the increase of PAWC. Note that the Δbiomass loss probability became stable when PAWC was over around 170 mm for wet sites. By contrast, there was no significant change in Δbiomass loss probability during 12 soils at dry sites.

The results indicated that the soil with higher PAWC was better to mitigate the drought impact on wheat growth and therefore to increase the wheat yield. We expected our research could guide stakeholders and growers to reduce crop yield loss by adjusting SWC to ensure a steady supply of water during drought conditions.

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