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Modelling limiting transpiration under high evaporative demand to improve wheat productivity in dry environments

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Abstract: In the face of climate change, increasing yield in crops like wheat is critical to provide sustainable food security to the growing population. Limited transpiration at high vapour pressure deficit (VPD) has potential to improve transpiration efficiency (TE), i.e. produce "more crop per drop", and ultimately increase yield in dry environments (Collins et al., 2021; Collins and Chenu, 2025). Assessing the impact of this trait on water consumption, biomass accumulation and yield formation requires the application of dynamic crop models to simulate physiological and environmental processes at a suitable time scale and across a wide range of environments. Here, a new module that enables the simulation of atmospheric (VPD) and edaphic water effects on transpiration and biomass production was developed and evaluated in the new generation of Agricultural Production Systems sIMulator (APSIM-NextGen). The new module generates the diurnal pattern of temperature, VPD and solar radiation and calculates biomass assimilation and water consumption at an hourly time scale. The model was employed to assess the value of the limited-transpiration trait at 60 locations across the Australian wheatbelt under the current climate and a future climate scenario with representative projections of rainfall, temperature and CO_2 concentration for 2050. Spatial patterns of the impact of the limited-transpiration trait on cumulative transpiration, biomass at maturity and grain yield were investigated under both climate scenarios. Overall, limiting transpiration at high evaporative demands appears to be a promising trait for selection by breeders, especially in drought-prone environments where crops heavily rely on stored soil moisture.

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