Will modifying soil water holding capacity increase the resilience of southern Australian crop-livestock farms to climate change?

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Abstract: Southern Australia is expected to face a warmer and drier climate in near future that will affect the dryland crop-livestock farming enterprises. As soil provides a buffer to store water between rainfall events, a suggested climate adaptation option is to reduce subsoil constraints (physical or chemical) to increase the soil plant available water capacity (PAWC). The considerable costs to modify the subsoil raises a question of how much PAWC needs to be increased and how often the increased PAWC would be advantageous. This research examines the effect of increasing PAWC from 40 to 120 mm in 20 mm increments on wheat and pasture production along a climate transect from 385 to 219 mm mean growing season rainfall during the historic climate and in two potential climate projections for 2030: moderate warming with little changes in rainfall, and more severe warming with declining rainfall.

Biophysical simulation models of integrated crop-livestock systems were constructed by linking APSIM (V7.7) to GRAZPLAN using the AusFarm environment (V1.4.12).

Locations and projected future climates with higher rainfall gained the most from an increased PAWC. Not only was this evident in an increase in average yields of pasture and wheat but also in the frequency of years when there was a benefit. In higher rainfall conditions a larger PAWC increased wheat yield by at least 10% in 95% of years, compared to only 60% of years in lower rainfall conditions. A larger PAWC was of no benefit in very dry conditions. Overall productivity gains diminished not only as rainfall increased, but also as PAWC increased. Pasture production showed little benefit of PAWC above 60 mm presumably due to shallower roots or rainfall more closely matched to water demand, while wheat yield in a PAWC of 80 mm averaged over 90% of that in a PAWC of 120 mm.

Wheat yield was reduced by water stress experienced during the growth cycle with the seasonal distribution of rainfall affecting the severity and timing of water stress and yield components of grain number and grain size. However, wheat grown in soils with higher PAWC had less water stress even under the same rainfall conditions. This was due in part to greater availability of water because of reduced water loss from deep drainage and increased soil water storage between rotations.

Modifying PAWC will not counteract an extreme drying trend. In some seasons there will be little benefit of modifying the subsoil because the rainfall pattern is extremely low or is regular and matched to crop and pasture requirements. In other seasons when rainfall is high a larger PAWC will be of benefit as the increased buffering capacity of the soil will assist with carryover of water from a wet run of days to a dry period. Modifying the subsoil raises complex questions of nutrition, engineering and farm management economics. However, simulation modelling using a transect from wetter and drier sites in both current and future climates contributes to discussion on management of climate risk in the coming decades and effective adaptation options for future climates.

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