Constraints and opportunities to sustain future wheat yield and water productivity in semi-arid environment

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Abstract

Sustaining future wheat production is challenged by anthropogenically forced climate warming and drying led by increased concentration of greenhouse gases all around the globe. Warming stresses, originating from the elevated CO_2 concentration, are continuously reported to have negative impacts on wheat growth and yield. Yet, elevated CO_2 concentration, despite being disparagingly blamed for promoting warming, is also associated with a phenomenon called CO_2 enrichment; in which wheat yield can improve due to the enhanced photosynthesis rates and less water loss through transpiration. The conflicting nature of climate warming and CO_2 enrichment and their interplay can have specific implications under different environments. It is established form the field and simulation studies that the two contrasting phenomena would act severely in their own respect under arid and semi-arid environments. Wheat is a dietary staple for masses in Pakistan. The country' s wheat production system is under constant stress to produce more from irrigated agricultural lands, primarily lying under arid to semi-arid environments, to meet the rapidly growing domestic needs. This work comprehensively examines the warming impacts over wheat yield and water productivity (WP), with and without the inclusion of CO_2 enrichment, under semi-arid environment of Punjab which is the largest agricultural province of Pakistan. Future wheat yields and WPs were simulated by FAO developed AquaCrop model v 5.0. The model was run using the bias-correction climate change projections up to 2080 under two representative concentration pathways (RCP) scenarios: 4.5 and 8.5. Wheat yield and WPs decreased without considering the CO_2 enrichment effects owing to the elevated irrigation demands and accelerated evapotranspiration rates. The results suggested that CO_2 enrichment could help maintain the current yield and WPs levels during the 2030s (2021-2050); however, it might not withhold the negative climate warming impacts during the 2060s (2051-2080). Furthermore, 10 - 20 day backward shift in sowing dates could also help ease the constraints imposed by climate warming over wheat yields and WPs. Although, CO_2 enrichment showed promises to counteract the adverse climate warming impacts but the interactions between climate warming and CO_2 concentrations were quite uncertain and required further examination.

Keywords: climate change, wheat yield, water productivity, semi-arid environment

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