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Integrating Tillage and Mulching Practices as an Avenue to Promote Soil Water Storage, Growth, Production, and Water Productivity of Wheat under Deficit Irrigation in Arid Countries

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Abstract: Ensuring food security with limited water resources in arid countries requires urgent development of innovative water-saving strategies. This study aimed to investigate the effects of various tillage and mulching practices on soil water storage (SWS), growth, production, irrigation water use efficiency (IWUE), and water productivity (WP) of wheat under full (FL) and limited (LM) irrigation regimes in a typical arid country. The tillage practices comprised the conventional tillage (CT) and reduced tillage (RT), each with five mulching treatments (MT), including non-mulched (NM), plastic film mulch (PFM), wheat straw mulch (WSM), palm residues mulch (PRM), and a mixture of wheat straw and palm residues at 50/50 ratio (MM). Results showed higher SWS at different measured time points in CT than RT at 20–40 cm, 40–60 cm, and 0–60 cm soil depth under FL regime, and at 40–60 cm under LM regime, while the opposite was observed at 0–20 cm and 20–40 cm soil depth under LM regime. SWS at different soil depths under MT, in most cases, followed the order of PFM > PRM ≈ MM > WSM > NM under FL, and PFM ≈ PRM > MM > WSM > NM under LM regimes. No significant differences were observed for traits related to growth between CT and RT, but RT increased the traits related to yield, IWUE, and WP by 5.9%–11.6% than did CT. PFM and PRM or PRM and MM showed the highest values for traits related to growth or yield, IWUE, and WP, respectively. No significant differences in all traits between CT and RT under the FL regime were observed, however, RT increased all traits by 8.0–18.8% than did CT under the LM regime. The yield response factor (Ky) based on plant dry weight (Ky_{PDW}) and grain yield (Ky_{GY}) under RT was acceptable for four MT, while Ky_{GY} under CT was acceptable only for PRM, as the Ky values in these treatments were <1 under the LM regime. The interrelationships of plant dry weight (PDW), grain yield (GY), IWUE, and WP with evapotranspiration (ET), and of WP and IWUE with PDW and GY were best described by a second-order polynomial. SWS measured before irrigation exhibited strong linear relationships with PDW and GY (R^2 range 0.57 to 0.92), while they exhibited a second order polynomial and moderate correlation with IWUE and WP (R^2 range 0.29 to 0.54). Overall, combining RT with plant residue mulching, particularly using the readily available palm residues in sufficient amount is a feasible and sustainable water-saving strategy for enhancing wheat yield and WP in irrigated arid countries, such as Saudi Arabia.