

A decade progress of conservation agriculture-based systems on in situ soil and water conservation and adaptation to climate change in the Ethiopian drylands

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Abstract

Long-term in situ soil and water conservation experiments are rare in sub-Saharan Africa, particularly in Eastern Africa. Conservation agriculture (CA)-based systems aims at building resilience against soil degradation via reducing soil loss and drought by increasing productive green water by reducing runoff and soil evaporation while improving crop yield (1) by minimizing soil disturbance, (2) by retaining crop residue, (3) by using crop rotations and (4) by adding in situ soil and water conservation (SWC) tillage practices (terwah and derdero) in crop fields. We studied the impact of two CA-based systems (derdero+ (DER+) and terwah+ (TER+)) on soil moisture, runoff, soil evaporation, soil loss, water use efficiency and crop productivity in permanently kept plots in northern Ethiopia 10 years (2005-2014) after its inception. The two RCA practices: (i) DER+ is a bed and furrow planting system, where beds remain unploughed, furrows are tilled once at planting time and 30% of crop residue is retained. (ii) TER+ is ploughed once at planting, furrows are made at 1.5 m interval, creating fresh broad beds, and 30% crop residue is retained. These RCA practices were compared against conventional tillage (CT) characterized by a minimum of three tillage operations and complete removal of crop residues. DER+ and TER+ were based on local practices that were modified to comply with conservation agriculture (CA) principles. All plowing as well as the maintenance of the furrows of the permanent raised beds was done using a local ard plow called mahresha. Wheat, teff, barley and grass pea were grown in rotation. Glyphosate was sprayed at 2 l ha⁻¹ to control weeds before crop emergence, starting from 2007 with DER+ and TER+. Runoff was collected at the lower end of each plot in calibrated runoff collectors after each runoff event. Soil water content was measured using the gravimetric method at 5 to 6 day intervals. Significantly different ($P < 0.05$) runoff coefficients (%) averaged over 10 yrs were 14, 22 and 30 for DER+, TER+ and CT, respectively. Mean soil losses of 10 yrs were 3, 12 and 18 t ha⁻¹ y⁻¹ in DER+, TER+ and CT, respectively. Soil water storage (0–80 cm soil depth) during the growing season was always highest with DER+ followed by TER+ and CT, whereas the opposite trend was observed for runoff. Although improvements in crop yield were observed, a period of at least three years of cropping was required before they became significant. The grain and straw yield of wheat in 2009 was increased from 1.6 and 3.7 t ha⁻¹ with CT to 2.6 and 5.2 t ha⁻¹ with DER+, respectively. The experiences presented in this paper from northern Ethiopia indicate that for

smallholder farmers in semi-arid areas, CA-based systems constitute a field rainwater conservation and soil fertility improvement strategy that increase agro-ecosystems resilience to climate change (such as drought) and thus improve crop productivity. Adoption of CA systems (DER+ and TER+) in the study area require further work to improve smallholder farmers' awareness on benefits, to guarantee high standards during implementation and to design appropriate weed management strategies.

Keywords: Conservation agriculture, Vertisols, green water, permanent raised bed, crop residue