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Soil CO_2 Emissions on Sloping Lands: Spatial Variations and Slope Sensitivity

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Erosion induced CO_2 emissions have been extensively studied across different scales from plots to watersheds. While slope is the essential element to initiate soil erosion and sediment transport, the potential effects of slope gradients and slope positions to soil CO_2 emissions have not yet been systematically studied.
In this study, six east-facing plots of 100 m2 (20 m $\times$ 5 m) with increasing slope gradients of 0.5o (S 0.5), 1o (S1), 3o (S3), 5o (S5), 10o (S10) and 20o (S20), with identical soil preparation and wheat, were established in an eroded gully of the semi-arid Loess Plateau, China. Soil temperature, moisture and CO_2 emissions were detected once every week for two years from October 2013 to September 2015. Runoff and sediment yield were collected after detectable natural rainfall events. Surface litter, fine root biomass and aboveground biomass and SOC content of surface soil were also measured once a year.
Our results show that: 1) annual soil CO_2 emission rates exponentially decreased with slope gradients, on average from 843.7 g C m$-$2 year^{-1} at S0.5 to 388.2 g m$-$2 at S20. This is attributed to increasing C loss through runoff and sediment discharge from slopes of greater gradients (0.075 m3 year^{-1} from S0.5 vs. 63.8 m3 year^{-1} from S20), and also in part attributed to limited fine root growth on steeper slopes. 2) On each slope, CO_2 emission rates also differed among slope positions, with CO_2 emissions 61% greater from upper than lower slopes. This agrees well with the erosion-induced spatial redistribution of SOC and soil moisture along the slope. Overall, slope angle affected soil moisture content and redistribution, and as a consequence, the fine root biomass, crop yields and CO_2 emissions within slopes. These impacts must be adequately accounted for to fully understand the environmental impacts of agricultural management on the regional agro-ecosystem.