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Soil loss hinders the restoration potential of tree plantations on highly eroded ravine slopes

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Abstract

Purpose Soil erosion and loss threatens vast tracts of agricultural and non-agricultural land, worldwide. High soil erosion severely affects establishment of vegetation via effects on plant growth and productivity on already degraded lands. However, information on soil loss impact on tree plantation and their relationships is scarce in the ravine lands. Therefore, we assessed soil loss effects on tree growth and soil characteristics, and role of conservation measures in degraded ravine land.

Methods The study consisted of comparing three systems, i.e., terracing, trenching, and sole slope to observe the effects on soil erosion and the resultant losses. In first system, a terraced land was designed from ravine top to bottom by dividing the slope into the four plots. In second system, ninety-seven trenches sized 2.0 m × 0.5 m × 0.5 m were designed on slope, while in third system, a continuous slope was maintained. Twenty-seven trees were planted at 8 m × 8 m spacing in each system. In all the systems, annual runoff, soil loss, tree growth, biomass and carbon stock, and soil properties were observed for the 7 years.

Results Annual soil loss was recorded highest (5.1 t ha⁻¹ year⁻¹) in slope followed by trench (4.4 t ha⁻¹ year⁻¹) and terrace (3.8 t ha⁻¹ year⁻¹) systems, during the 7 years. In the slope system, increased soil loss resulted in the decreased tree height and collar diameter growth by 3–12% and 12–21%, respectively. Total biomass, carbon stock, and CO₂ sequestration declined by 44–86% with the increased soil loss on the slope during the same period. Tree canopy area was also recorded lower in the slope, compared to terrace and trench measures. The soil loss relationship with tree characteristics revealed that growth, biomass, carbon stock, and canopy area consistently declined with the increased soil loss. In soil, proportional loss of organic carbon (11–21%), nitrogen (10–13%), phosphorus (25–32%), and potassium (4–13%) was also observed with increased soil erosion on the slope, compared to conservation measures. In contrast, soil loss reduction in the terrace and trench based measures improved the tree growth, biomass, carbon stock, and soil properties during the same period.

Conclusion The soil loss negatively affected the tree growth, productivity and their restoration potential, while soil conservation measures showed strong potential to ameliorate the highly eroded ravine slopes. Therefore, tree plantations should be augmented with the appropriate soil and water conservation measures for achieving greater ecological and economic benefits in degraded ravine lands.

Keywords Soil loss · Growth · Productivity · Soil conservation · Restoration · Climate change mitigation

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