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Theme 3. Sustainability of grasslands- social and policy issues
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Reversing land degradation through grasses: a systematic meta analysis in the Indian tropics

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Introduction

Soil water infiltration influences potential top soil loss by erosion, as well as the partitioning of runoff into slow flow and quick flow. The aim of the work presented here was to critically review studies of the effects of grasses on reversing the process of land degradation and improving the soil infiltrability in the tropics, using a systematic review. The study area was divided into arable and non-arable conditions and the effect of grasses were deduced as grass strip and pastoral systems, respectively. I then applied meta-analysis to test the hypothesis that use of grasses as grass-strips in agriculture increases infiltration capacity and reduce soil erosion. Similarly the effects of grasses were analyzed in degraded pasture lands.

Materials and Methods

About 60 published papers and reports have been consulted for collecting the information on benefits of grasses in arresting soil erosion and run off. In addition, the relative efficiency of different grasses were analysed based on biomass production, soil binding capacity, carbon build up and improvement of soil quality. A systematic meta analysis was done to identify site specific grass species for different regions of India.

Results and Discussion

The overall result of the meta-analysis was that infiltration capacity increased on average approximately two-fold after planting grasses across the slopes in agricultural fields (95% confidence level). In case of Doon valley region, comparing the impacts on soil wetting pattern, infiltration rate and sorptivity under mature stands, it has been observed that *Chrysopogon fulvus* was found to be most promising grass species. The runoff data show that grass hedges had a significant effect on runoff reduction. On an average the study revealed that compared to control the overland flow reduced by 45%. The findings on 25 experiments clearly shows that as the rain proceeded, overland flow moved down slope into the grass hedges and water backed-up behind them, giving more opportunity time for the water to infiltrate the soil. Grass hedges facilitated the appearance of backed-up water above the filter strips, which resulted in sedimentation and substantial reduction in soil loss. Over and above, the amount of transported soil reduced by 59% in case of live hedges than that of the control. Similarly the analysis of the data revealed that the impact of grasses were more pronounced along with soil and water conservation measures in minimizing the losses of water (water saving by 63%) and soil (reduced soil loss by 61%). A total of 12 studies on grazing land management revealed that the benefits of stall feeding and controlled grazing could save about 42% water loss and 63% soil loss in sloppy lands. Grass hedges, either independently or in combination with soil conservation measures, caused a substantial reduction in nutrient losses, as compared to the control plots. Overland runoff significantly decreased by 65–88% and 15–38%, respectively to the *Pennisetum* and *Arundinella* hedges, and the percentage of such reduction increasing with slope and precipitation intensity. This response relative to composite slopes can be a more significant indication when operating at watershed scale since it integrates a multiplicity of conditions. Establishment of perennial grasses on degraded soils has been suggested as a means to improve soil quality and sequester carbon in the soil. Several studies have shown that the inclusion of grasses in the agricultural landscape often improves the productivity of system while providing opportunities to create C sinks. The amount of C sequestered largely depends on the specific system put in the place, the structure and function of which are, to a great extent, determined by environmental and socio-economic factors. About 6 fold increase of SOC content in soil has been observed in barren lands of Shivalik region through rehalilitation by *Arundo donex*. Other promising grass species identified for this region were Saccharum munja and bamboo which showed 3 fold improvements in soil structural stability. Limited information on soil organic carbon divulged that loss of carbon can be reduced to the extent of in Shivalik region. While some other studies indicated that carbon sequestration rate of 100 kg ha -1 ya-1 can be achieved by the use of grass hedge strips running across the slope especially in laterite soils of Konkan region. In the hilly region of North-eastern Himalaya, the alternative land use systems help in reducing soil erosion systems help in reducing soil erosion and SOC loss to a substantial extent. Higher root-biomass of the grasses, particularly *Paspalum*, Congosignal, Hamil and Makunie due to greater water transmission resulted in higher SOC in the soil profile. Following addition of organic matter through continuous root decay of these grasses increased water holding capacity as a result of increased the specific surface area. Additionally, these grasses helped in improving soil quality including soil hydro-physical characteristics and biological activities. Such improvement in soil properties have a direct bearing on C-sequestration (5 fold increase in SOC over control), long-term sustainability, reducing soil erosion (2-3 fold increase in of structural stability over control) in a complex, risk prone fragile ecosystem. The carrying capacities of pasture lands need to ascertain to determine the type of stock and duration and intensity of grazing. The continuous grazing of the pastures should be discouraged and deferred system followed for proper regeneration of grasses. The grasslands in middle and lower Himalayas are generally, in the most neglected state with low productivity. Grassland degradation is mainly resulted from anthropogenic factor. In this predominantly grazing region, excessive reliance on animal husbandry under a growing population has exerted great pressure on the land. As the maximum carrying capacity exceeded the critical limit, thus the overgrazing rate led serious grassland degradation. Pasture and grassland management practices such as controlled grazing, stall feeding of cattle and improvement in fodder production system should be made an integral component of all sustainable land development programme in the region.

Conclusion

Grasses are perhaps the best friend of soil and water conservations. Low and evenly distributed canopy and fibrous root systems with high soil binding capacity make grasses highly effective in controlling soil erosion. Efficacy for erosion control of various grasses was more than 95% hence their selection shall be based on the production potential of these grasss under given edaphic and agro-ecological condition. Realizing the importance of capacity for arresting soil degradation and biomass production, the promising grass species have been identified for various regions. It was identified that *Saccharum munja* and *Eulaliopsis binata* are most effective for Shivalik region of Punjab and Haryana while *Panicum maximum* and hybrid napier are very effective in humid tropical regions of lower Himalaya. The maintenance of soil quality resource is central to environmental ecosystem sustainability. It must be managed, conserved and protected by suitable measures for reversing the degraded state. The present analysis revealed that with respect to soil quality in sloppy arable areas of hilly regions (8.5 m ha), grass must be used as vegetative strip. Special emphasis on establishing grasses should be given to about 3 m ha degraded pasture lands and 3.5 m ha shifting cultivation areas to reverse the land degradation.