Making Rainfed Agriculture Sustainable by Fodder Grass Strips: An Affordable technology for Soil Conservation and Soil Health

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To make rainfed agriculture an economically viable enterprise for improving livelihood and welfare of farming community contributing around 40 percent of total food production in India, it is vital to implement best management practices to keep soils healthy, conserve agronomic inputs, minimize environmental impacts, and produce adequate yields. Increase in sudden down pour of rain invites high soil loss from the agricultural field leading to erosion of uppermost soil layer. Permanent fodder grass strips can be effective at checking nutrient removal and trapping sediment visa-a- vice meet the green fodder demand of small ruminants. However, Nutrients removed by erosion create a limitation to land productivity. It was being observed that grass system is useful for the improvement of other soil properties (soil physical and biological properties for example) related to soil erosion control, slope stabilization, and food production. Hence this study brought out the impact of grass strip based cropping system on sustainability of a rainfed farming. The field with grass strip improved in their soil quality from 0.39 to 0.52 in four years of time. This concept of growing grasses on both side of the field (in a strip of one meter) in loamy fine sand to sandy loam textured soils, improves soil health and significantly reduces runoff from the cropped field. A permanent belt of *Brachiaria ruziziensis and Stylosanthes hamata*, two-meter width, was established at every fifteen meters across the direction of slope reduced soil loss by 65-70 percent. This mechanization friendly technology provides sufficient green fodder for the small ruminants. Castor- Redgram rotation with fodder grass strips (especially *Brachiaria ruziziensis*) on upper and lower side of the slope fetched better crop productivity thus total returns increased from 1,37,022rupees/ ha to 1,78,689 rupees/ha. Use of grass strips is low-cost measures for soil conservation especially for slowing down run-off at sudden down pour with high intensity. This study may help researchers and its managers to help farmers with this low cost and viable technology.

Keyword: Grass strip, soil quality, surface runoff

Introduction:

Low risk bearing capacity of the farmers and erratic rainfall distribution leads to high crop yield fluctuations. Sudden down pour of rain invites high soil loss from the agricultural field leading to erosion of uppermost soil layer. Vegetated filter strips can be effective at checking nutrient removal and trapping sediment thus reducing soil loss from the field (Magette *et al.*, 1989). Meyer *et al.*, 1994 documented that grasses can reduce soil loss visa-vice meet the green fodder demand of small ruminants. However, with rising overall agricultural production costs, it will be vital to implement best management practices to keep soils healthy, conserve agronomic inputs, minimize environmental impacts, and produce adequate yields. Nutrients removed by erosion create a limitation to land productivity. It may remove a total of 4 kg of N, 1 kg of P, 20 kg of K and 2 kg of Ca from one tonne of soil (Pimentel *et al.*, 1993). It was being observed that grass system is useful for the improvement of other soil properties (soil physical and biological properties for example) related to soil erosion control, slope stabilization, and food production. Use of grass strips are one of the low-cost measures in soil conservation especially for slowing down run-off. Green fodder belts towards the slope end of field boundary and at the uppermost field boundary may hold the key to a cheap and practical solution for controlling soil erosion on a huge scale in tropical and semi-arid regions which can be adopted as new improved technology (Pushpanjali *et al.*, 2019). Quantitative data on their impact on soil quality, productivity and economic viability of such systems are very little and the impact of the grass strips on soil physico-chemical properties, and erosion control, have not been widely assessed for the rainfed cropping system in semi-arid environment. Hence this study brought out the impact of grass strip based cropping system on sustainability of a rainfed farming.

Methods:

Experimental plot with area of about 0.675 ha with random block design was laid out in Hayathnagar Research Farm of the Central Research Institute for Dryland Agriculture, Hyderabad, India (between 17.33 to 17.36 decimal degrees latitude and 78.58 to 78.61 decimal degrees, 515m above mean sea level). The area comes under semi-arid (dry) climate with mean annual rainfall of 746.2 mm. The soil is medium-textured red soil (Typic Haplustalf. In general, slope varies between 1 and 3% with some divergent and complex slopes conducive to considerable erosion hazard. Treatment imposed on 1, 2 and 3% slope land with 2-meter strip of *Brachiaria ruziziensis and Stylosanthes hamata* at lower end of the experimental plot (area:15*30 m^2), 2-meter strip of *Brachiaria ruziziensis and Stylosanthes hamata* at lower and upper end of the experimental plot and one experimental plot as without grass strip. For each grass strip, measurements for the various parameters investigated were taken on catenary arrangement (upper, middle and lower slope positions) within the terrace.

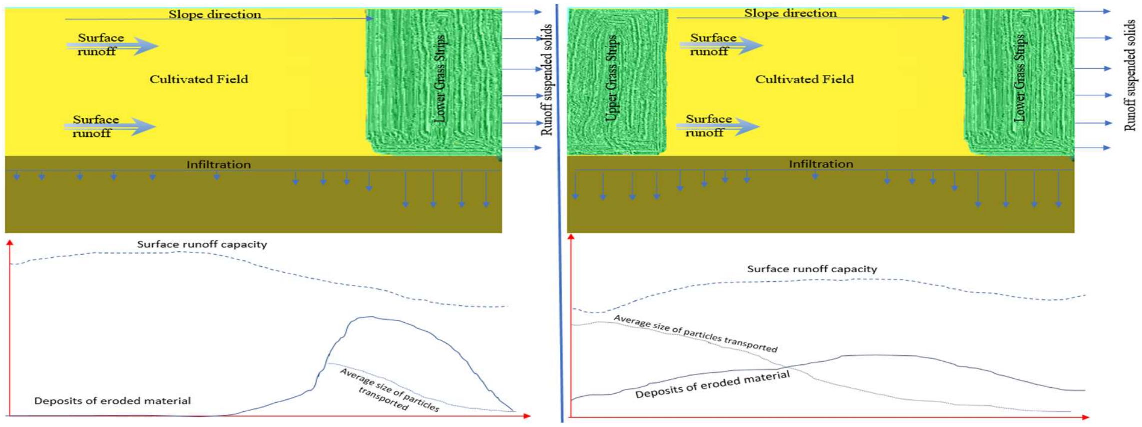

Fig.1 Schematic representation of the field with 2-meter grass strip and its effect on soil-water distribution.

The whole data collected were divided based on normal rainfall distribution (NRF) and deficit rainfall distribution (DRF) year. A period of two years *i.e.* 2016-2017 was DRF years for the study area while 2018-2019 was NRF years.

Results and Discussion:

Soil health and soil quality are terms used interchangeably to describe soils that are not only fertile but also possess adequate physical and biological properties to "sustain productivity, maintain environmental quality and promote plant and animal health" (Doron 1994).

Erosion budget

The analysis of the sediment concentration variability during a rainfall event shows the effect of rainfall and runoff intensities on the instantaneous sediment concentration. The combination of runoff infiltration and sediment trapping leads to a large reduction of sediment export downstream of the grass strip. Better soil infiltration leads to better soil environment (Bissonnais *et al.*, 2004). Soil loss from the field was reduced by 65% and 70% downstream of the 2-m grass strip on upper and down slope for the four observation seasons (fig. 2). Soil loss was limited to 1500-1000 kg/ha, whereas it reached 2000 and 2500 kg/ha when no grass strip was sown in all the slopes under observation.

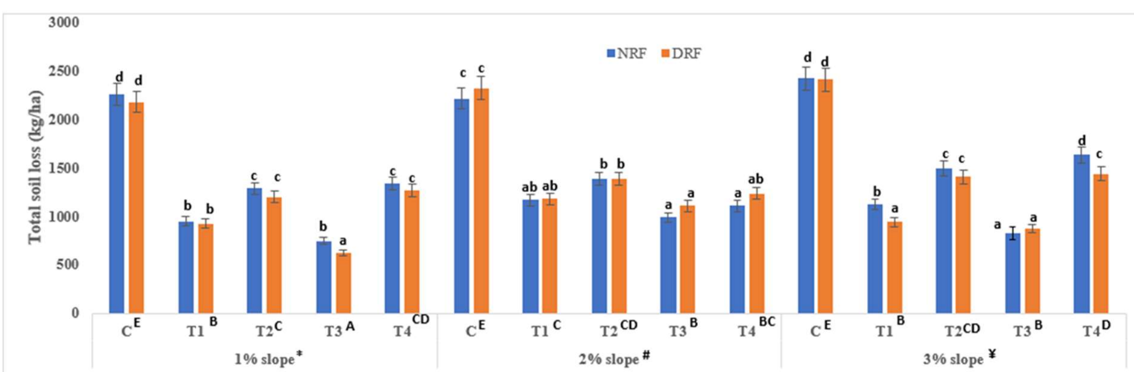

Fig 5. Effect of grass strip treatment on total soil loss through runoff sediments (kg/ha) across variable slopes (1-3%) in two different rainfall situations

[ABCDE] Differ significantly at 1% level of significance between the treatments irrespective of slopes
[abcd] Differ significantly at 5% level of significance between the treatments within a particular slope level at different rainfall situations.
[*#¥] Differ significantly at 1% level of significance between the slopes.
T_1, top and bottom *Stylosanthes* strip; T_2, Only bottom strip of *Stylosanthes*; T_3, top and bottom *Brachiaria* strip; T_4, only bottom strip of *Brachiaria.*

<u>*Soil quality*</u>

Soil quality as the fundamental first step to environmental improvement (Hebblethwaite *et al.*, 2008), introduction of multiple strips of grasses may benefit the adjacent crop strips because pairing grassland into croplands increases SOC, labile C, and microbial biomass (Pushpanjali and josily, 2019, Salehin *et al.*, 2020). Soil quality for the experiment was being calculated for each year with 16 physico-chemical and biological soil parameters e.g. Soil organic carbon, available nitrogen, phosphorous, potassium, micronutrient and macronutrient, soil aggregates, Infiltration etc. It was observed that, the soil quality of the control plot with no grass strip slightly deteriorated as year passed. The field with grass strip improved in their soil quality from 0.39 to 0.52 in due course of time (fig.3).

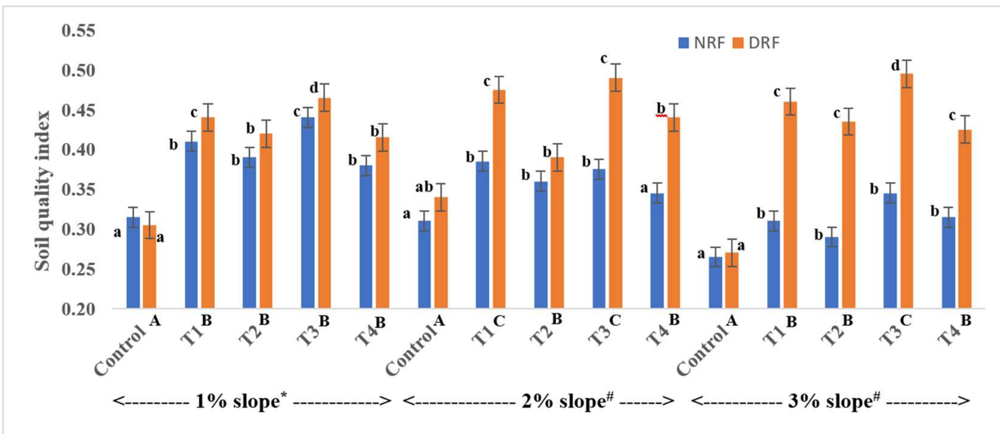

Fig 3. Effect of grass strip treatment on soil quality index across variable slopes (1-3%) in two different rainfall situations

[ABC] Differ significantly at 1% level of significance between the treatments irrespective of slopes.
[abcd] Differ significantly at 5% level of significance between the treatments within a particular slope level at different rainfall situations.
[*#] Differ significantly at 5% level of significance between the slopes.
T_1, top and bottom *Stylosanthes* strip; T_2, Only bottom strip of *Stylosanthes*; T_3, top and bottom *Brachiaria* strip; T_4, only bottom strip of *Brachiaria.*

<u>*Fodder for small ruminants*</u>

Fodder grass strips can be maintained for years and with positive potential to prevent sheet erosion and in addition provides forage for ruminants (Pankaj *et al*., 2020). A biomass yield of more than 7-18 t/ha was obtained during different years in case of leguminous fodder, *Stylosanthes hamata*, however, a biomass yield of 18-33 t/ha was obtained in same year in case of non-leguminous fodder, *Brachiaria ruziziensis*. The leafiness varied from 40% to 80% during different seasons of the year in both the fodder crops. Based on the fodder yield and nutrient content, the number of sheeps (Deccani breed) which were reared from the available biomass varied from 20-45 both in case of *Stylosanthes hamata* and *Brachiaria ruziziensis* grass fodder. Palatability (% of offered feed) of both the fodder varied from 65-100% when

Stylosanthes was used, however, it varied from 40-90% when *Brachiaria* was used. The average daily gain (gm/d) observed in Deccani sheep reared on these two chopped fodders varied from 15-35 gm/d in case of *Brachiaria* and 20-45 gm/d in case of *Stylosanthes* fodder. Cutting of green fodder should be done at 90 days after establishment and subsequently every 60 days. Thus, a minimum of five cuts per year can be harvested from the permanent grass belt. This bed can be maintained for several years and has the potential to prevent the sheet erosion apart from providing forage to the ruminants.

Economic benefits

The adoption and abandonment of particular technology are driven by the economic benefits (Josily *et al*., 2020) the farmers get from that technology. The net returns of all treatments and benefit-cost (BC) ratio of the treatments were calculated for normal and deficit rainfall years. *Brachiaria* strip at upper and lower side of field had higher BC ratio in 1% (2.50 in DRF years and 3.38 in NRF years) and 3% (2.59 in DRF years and 3.42 in NRF years) slope. While strip of *Stylosanthes* at upper and lower side had 2.66 (DRF years) and 3.50 (NRF years) at 2 % slope. Castor- Redgram rotation in cropping system with striped grass on upper and lower side of the slope fetched better crop productivity thus total returns increased from 1.37 Lakh rupees/ ha to 1.79 Lakh rupees /ha.

To the farmers' field

The same technology was taken to the farmer's field to show at the field level under their own conditions. Farmers were very happy to apply this technology as this allows them to harvest crops on the same plot and additionally supporting their small ruminants with fresh green fodder.




Photos: Planting to harvesting - in farmer's field

Conclusions:
Fodder Grass Strips on both side of the field slope has several natural resource management (NRM) benefits that include prevention of soil and nutrient loss, increased infiltration opportunity time inside the standing crop field and biomass yield of 10–15 t ha^{-1} in addition to the concurrent crop/grain yield. Thus, in lieu of erratic high intensity rainfalls happening frequently in this region, it is a very good technology for farms of small and marginal farmers in semi-arid tropics, facing great challenge of restricting erosion from their land as well as improving soil health.

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