chemistry proceedings

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Proceeding Paper

Fodder Grass Strips for Soil Conservation and Soil Health †

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† Presented at the 1st International Online Conference on Agriculture—Advances in Agricultural Science and Technology, 10–25 February 2022; Available online: https://iocag2022.sciforum.net/.

Abstract: To make rainfed agriculture an economically viable enterprise for improving the livelihood and welfare of the farming communities contributing around 40 percent of the 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. Increases in the sudden downpour of rain invites a high amount of soil loss from agricultural fields, eroding the uppermost soil layer. Permanent fodder grass strips effectively trap sediments and check nutrient removal from soil on one hand and on other meet the green fodder demands of small ruminants. However, nutrients removed by erosion create a limitation on land productivity. It has been observed that grass systems are 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 systems on the sustainability of rainfed farming. Fields with grass strips improved their soil quality from 0.39 to 0.52 over a four-year period. This concept of growing grasses on both sides of a field (in a one-meter strip) in areas of loamy fine sand to sandy loam textured soils improves soil health and significantly reduces runoff from cropped fields. A permanent belt of *Brachiaria ruziziensis* and *Stylosanthes hamata* in two meter widths was established at every fifteen meters across the direction of the slope and reduced soil loss by 65–70 percent. This mechanization of friendly technology provides sufficient green fodder for small ruminants. A castor–redgram rotation with fodder grass strips (especially *Brachiaria ruziziensis*) on the upper and lower sides of the slopes fetched better crop productivity, and thus the total returns increased from 137,022 rupees/ha to 178,689 rupees/ha. The use of grass strips is a low-cost measure for soil conservation, especially for slowing down the run-off from sudden downpours of high intensity. This study may aid researchers and managers in helping farmers with this low-cost and viable technology.

Keywords: grass strip; soil quality; surface runoff

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Citation: Pushpanjali; Reddy, K.S.; Samuel, J.; Pankaj, P.K.; Reddy, A.G.K.; Rohit, J.; Reddy, K.S. Fodder Grass Strips for Soil Conservation and Soil Health. *Chem. Proc.* **2022**, *10*, 58. https://doi.org/10.3390/IOCAG2022-12189

Academic Editor: Raimundo Jimenez-Ballesta

Published: 10 February 2022

1. Introduction

A low risk bearing capacity of farmers and erratic rainfall distribution lead to high crop yield fluctuations. The sudden downpour of rain invites high erosion from an agricultural field. Vegetated filter strips can be effective at checking nutrient removal and trapping sediment, thus reducing soil loss from the field [1]. Meyer et al. (1995) [2] documented that grasses can reduce soil loss via meeting the green fodder demands 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 on 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 ton of soil [3]. It has been observed that a grass system is useful for improving other soil properties (the soil's physical and biological properties, for example) related to soil erosion control, slope stabilization, and food production. The use of grass strips is one of the low-cost measures in soil conservation, especially for slowing down run-off. Green fodder belts towards the slope end (Figure 1) of a 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 a new improved technology [4]. There is little quantitative data on the impact on soil quality, productivity, and economic viability of such systems, and the impact of grass strips on soil's physico-chemical properties and on erosion control has not been widely assessed for rainfed cropping systems in semi-arid environments. Hence, this study brought out the impact of grass-strip-based cropping systems on the sustainability of rainfed farming.

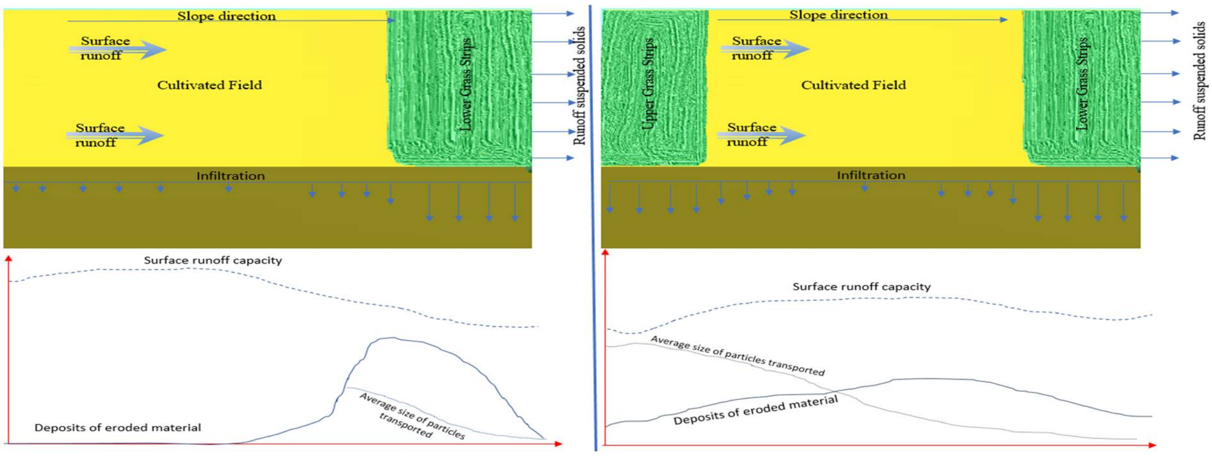

Figure 1. Schematic representation of the fields with 2 m grass strips and the effect on soil–water distribution.

2. Methods

An experimental plot with an area of about 0.675 ha with a random block design was laid out in the 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, 515 m above mean sea level). The area is classified as having a semi-arid (dry) climate with a mean annual rainfall of 746.2 mm. The soil is medium-textured red soil (Typic Haplustalf). In general, the slope varies between 1 and 3%, with some divergent and complex slopes conducive to a considerable risk of erosion. Areas with 1, 2, and 3% slopes were treated with a 2 m strip of *Brachiaria ruziziensis* and *Stylosanthes hamata* at the lower end of the experimental plot (area: 15×30 m^2), a 2 m strip of *Brachiaria ruziziensis* and *Stylosanthes hamata* at the lower and upper ends of the experimental plot, and one experimental plot was without grass strips. For each grass strip, measurements for the various parameters investigated were completed on a catenary arrangement (upper, middle, and lower slope positions) within the terrace.

All of the data collected were divided based on a normal rainfall (NRF) distribution and deficit rainfall (DRF) distribution year. A period of two years, i.e., 2016–2017, was classified as the DRF years for the study area, while the period 2018–2019 was the NRF years.

3. 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" [5].

3.1. 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 a better soil environment [6]. Soil loss from the field was reduced by 65% and 70% downstream of the 2 m grass strips on the upper and lower slopes for the four observation seasons (Figure 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.

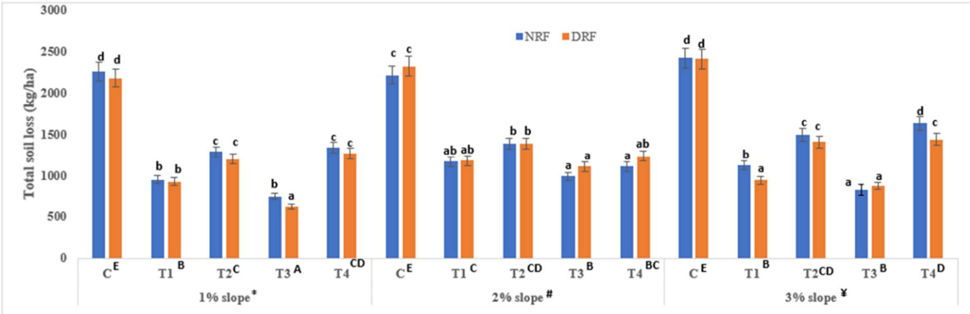

Figure 2. Effects of grass strip treatment on total soil loss through runoff sediments (kg/ha) across variable slopes (1–3%) in two different rainfall situations. ABCDE differ significantly at a 1% level of significance between the treatments, irrespective of the slopes. abcd differ significantly at a 5% level of significance between the treatments within a particular slope level at different rainfall situations. *#¥ differ significantly at a 1% level of significance between the slopes. T1, top and bottom *Stylosanthes* strip; T2, only bottom strip of *Stylosanthes*; T3, top and bottom *Brachiaria* strip; T4, only bottom strip of *Brachiaria*.

3.2. Soil Quality

Soil quality is the fundamental first step to environmental improvement [7], and the introduction of multiple strips of grasses may benefit the adjacent crop strips because pairing grassland into croplands increases SOC, labile C, and microbial biomass [8,9]. Soil quality for the experiment was calculated for each year using 16 physico-chemical and biological soil parameters, e.g., soil organic carbon, available nitrogen, phosphorous, potassium, micronutrients and macronutrients, soil aggregates, infiltration, etc. It was observed that the soil quality of the control plot with no grass strips slightly deteriorated as the year passed. The fields with grass strips improved in their soil quality from 0.39 to 0.52 in over the measured period of time (Figure 3).

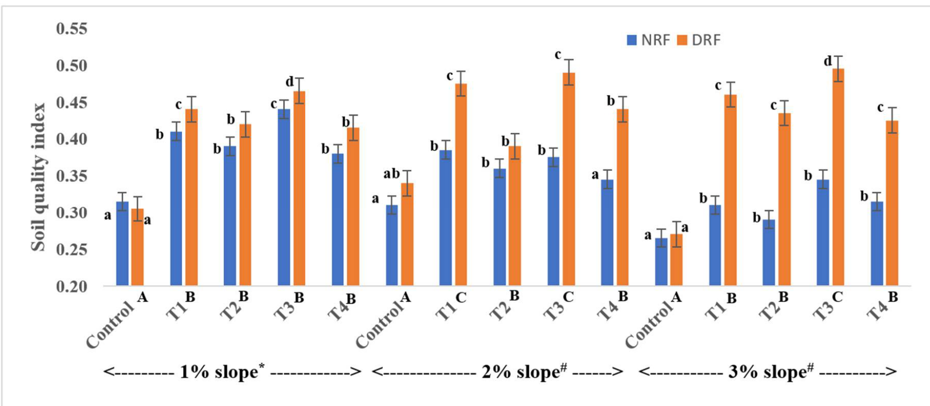

Figure 3. Effect of grass strip treatment on soil quality index across variable slopes (1–3%) in two different rainfall situations. ABC differ significantly at a 1% level of significance between the treatments, irrespective of slope. abcd differ significantly at a 5% level of significance between the treatments within a particular slope level at different rainfall situations. *# differ significantly at a 5% level of significance between the slopes. T1, top and bottom *Stylosanthes* strip; T2, only bottom strip of *Stylosanthes*; T3, top and bottom *Brachiaria* strip; T4, only bottom strip of *Brachiaria*.

3.3. Fodder for Small Ruminants

Fodder grass strips can be maintained for years, with a positive potential to prevent sheet erosion, and, in addition, provide forage for ruminants [10]. A biomass yield of more than 7–18 t/ha was obtained during different years in the case of a leguminous fodder, *Stylosanthes hamata*; however, a biomass yield of 18–33 t/ha was obtained in the same year in the case of non-leguminous fodder, *Brachiaria ruziziensis*. The leafiness varied from 40% to 80% during different seasons of the year in both of the fodder crops. Based on the fodder yield and nutrient content, the number of sheep (Deccani breed) which were reared from the available biomass varied from 20–45 both in the case of the *Stylosanthes hamata* and *Brachiaria ruziziensis* grass fodders. Palatability (% of offered feed) of both the fodders 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 the case of *Brachiaria* and 20–45 gm/d in the case of *Stylosanthes* fodder. The cutting of green fodder should be done at 90 days after establishment and subsequently at 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 sheet erosion, apart from providing forage for ruminants.

3.4. Economic Benefits

The adoption and abandonment of a particular technology is driven by the economic benefits [11] the farmers receive from that technology. The net returns of all treatments and the benefit–cost (BC) ratios of the treatments were calculated for normal and deficit rainfall years. *Brachiaria* strips at the upper and lower sides of a field had higher BC ratios 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) slopes, while strips of *Stylosanthes* at the upper and lower sides had 2.66 (DRF years) and 3.50 (NRF years) at a 2% slope. Castor–redgram rotations in cropping systems with stripped grass on the upper and lower sides of the slopes fetched better crop productivity, and thus total returns increased from 1.37 Lakh rupees/ha to 1.79 Lakh rupees/ha.

3.5. To the Farmers' Field

The same technology was taken to farmers' fields (Figure 4) to demonstrate these results at the field level and under their own conditions. The farmers were very happy to apply this technology as it allowed them to harvest crops on the same plot and, additionally, it supported their small ruminants with fresh green fodder.

Figure 4. Photos: Planting to harvesting in farmers' fields.

4. Conclusions

Fodder grass strips on both sides of a field's slopes have 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 yields of 10–15 t ha^{-1} in addition to the concurrent crop/grain yield. Frequent occurrence of erratic, high-intensity rainfalls in semi-arid tropics, made this technology much more feasible for small and marginal farmers having few ruminants to support with green fodder.

Author Contributions: Conceptualization, P., K.S.R. (Konda Srinivas Reddy), K.S.R. (Kotha Sammi Reddy); methodology, P., J.S., P.K.P., A.G.K.R., J.R.; validation, P., J.S.; formal analysis, P., P.K.P., J.S.; investigation, P., K.S.R. (Konda Srinivas Reddy), J.S., P.K.P., A.G.K.R., J.R.; resources; writing—original draft preparation, P.; writing—review and editing P., K.S.R. (Konda Srinivas Reddy), J.S., P.K.P., A.G.K.R., J.R. and K.S.R. (Kotha Sammi Reddy), supervision, K.S.R. (Kotha Sammi Reddy). All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Experimental data will be available for reasonable reasons from the first author.

Acknowledgments: The authors express their sincere thanks to all the staff of the ICAR-CRIDA and the Director of the ICAR-CRIDA for their constant support throughout the project " Impact of Grass Strip on Soil Carbon Sequestration and Soil Physical Properties in Cropped Field Under Semi-Arid Environment".

Conflicts of Interest: The authors declare no conflict of interest.

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