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Impact of soil and water conservation measures on sediment yield and productivity of finger millet

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Abstract
The study was conducted at AICRP&DA, UAS, GKVK, Bengaluru, to evaluate the impact of contour trenches on sediment yield and productivity of finger millet being test crop. Experiment with treatment *viz*., trench T_1 (contour trenches at 10 m interval), T_2 (contour trenches at 25 m interval) and also runoff plots treatment with different slope *viz*., T_3 (1.9%), T_4 (2.24%) and T_5 (2.1%). T_1 showed lower runoff (150.98 mm) and soil loss (3.011 tonnes/ha) resulted in higher conservation of soil moisture content, whereas higher runoff and soil loss (230.43 mm and 4.218 tonnes/ha) was found in T_4 resulted in conserving lower soil moisture content. Similarly, T_1 recorded higher grain yield (2512 kg/ha) and straw yield (3768 kg/ha) compared to all other treatment due to the availability of higher moisture content by reduced runoff and soil loss, Also T_1 resulted in increasing net returns (53923 Rs.ha^{-1}) and B:C ratio (3.09). From this investigation, it is concluded that contour trenches at 10 m spacing was found to be efficient in reducing both runoff and soil loss and increasing the productivity of finger millet crop.

Keywords: Runoff, soil moisture, evapotranspiration, deep percolation, water balance

Introduction

Soil is an important natural resource, which is composed of organic matter, minerals, gases, liquids and organisms that together for all land use activities to meet the requirement of food, feed, fuel, fibre *etc*., of mankind. Soil and water are always been vital for sustaining life and becoming more limited to meet the demands of increasing population. These resources are already under intensive use and misuse. Soil erosion by water is one of the main problems in the agriculture sector that causes land degradation and reduces the agricultural productivity. Agricultural activities are responsible for 75 per cent of global soil erosion, affecting the 80 per cent of the world cultivated soils and adversely impacting food production on 40 per cent of the agriculture land. It is estimated that out of 329 M ha of total geographical area in India, about 146.82 M ha suffers from soil erosion and land degradation. In India on an average, annual top soil removal due to erosion is to the tune of 53,500 M t. (Lavelle *et al*., 2001) [5]

Soil erosion is the detachment and transportation of soil particles by erosive agents, most commonly water and wind. Soil erosion remains the world biggest environmental problem, threatening sustainability of both plants and animals on the planet earth. Over 65% of the soil on earth is said to have displayed degradation phenomena as a result of soil erosion, salinity and desertification (Abegunde *et al*., 2006) [1]. Soils generally take thousands of years to develop from their original parent material and natural erosion is a part of this development process. Vegetation protects soil and its roots hold and bind soil particles together. Therefore in long-term natural systems (e.g., forests and prairies) soil losses in upland areas may be relatively minimal. However, human activities, particularly agricultural production, forestry, mining, and construction can disturb or destroy vegetation, loosen soil and greatly increase the risk of soil erosion losses from subsequent rainfall, runoff, and/or windstorm events. Soil erosion and sedimentation of eroded materials at locations away from the point of detachment are costly to individuals and society as a whole due to loss of productive topsoil and applied nutrients on croplands which affect and damage to crops and crop yield, and pollution of water (Flanagan, 2002) [3].

Soil erosion by running water has been recognized as the most severe hazard threatening the protection of soil as it reduces soil productivity by removing the most nutrient rich top soil.

In the world map on the status of human-induced soil degradation, it is accounted that loss of top soil and terrain deformation due to soil erosion are the consequences of deforestation, removal of natural vegetation and overgrazing in the mountainous regions (Shrestha, 1997) [8].

Low agricultural productivity in the semi-arid region is not only due to land degradation, but also caused by moisture stress. In dry land areas, rainfall is low and uncertain, it varies widely over time and space, resulting in conditions of recurring drought and sometimes floods. These areas also do receive occasional heavy individual storms. Rainfall patterns are often erratic and unpredictable throughout the dry land regions and crops can suffer from moisture deficit and drought even during normal rainfall periods. (Wessels *et al*., 2007) [10]

Contour trench method of land development for soil and water conservation under dryland conditions are the excavated depression across the land slope with the purpose of preventing soil erosion by trapping and absorbing sediments and runoff respectively. Contour trenches will help to collect runoff water and also breaks the continuous slope of the ground and it results in reducing the velocity of runoff water. The reduced velocity of runoff is resulted in better opportunity time for infiltration reflected through reduced runoff and soil loss and facilitate to percolate down into the soil profile (Karuku 2018) [4]. Runoff, soil and nutrients losses are sever in sloppy areas, which can be controlled by putting the continuous contour trenches. In recent years, such contour trench method of land development is recommended to the formers in the Karnataka state. The cross section of the trenches can be of any size and shape like square, rectangle, trapezoidal or triangle.

To investigate the impact of rainfall on runoff and soil loss in finger millet cropping system as a test crop and also to find the effect of contour trenches on runoff and soil loss was carried out during the year 2019-2020 at the All India Coordinated Research Project on Dry Land Agriculture, UAS, GKVK, Bengaluru.

Material and Methods

Experimental site

The present study was conducted at the All India Coordinated Research Project on Dry Land Agriculture, UAS, GKVK, Bengaluru. Geographically it is located at 12°58' North latitude and 77^0 35' East longitudes with an altitude of 924 meters above MSL. The experimental site comes under Eastern Dry Zone of Karnataka. The experimental site predominantly consists of sandy loam soil. The annual average rainfall of the region is 921 mm and more than 70 per cent of the rain received during the *Kharif* season (Manson).

Treatment details

Runoff from the three runoff plots *viz*; T_1, T_2 and T_3 where the runoff collected in the individual cisterns having the storage capacity of 9.2 m^3. As part of treatments, the T_1 and T_2 runoff plots are constructed with the trapezoidal shape trench having the cross sectional area of 0.09 m^2across the slope for a distance of 4 m plot width. The T_1 is constructed with the trench at 10 m horizontal interval. There are two trenches constructed in this treatment having the total storage capacity of 73.6 m^3. The T_2 is constructed with the trapezoidal shape trench at 25 m horizontal interval. The T_2 is having single trench with the total runoff storage capacity of 36.8 m^3. The runoff in excess of the trench storage capacity can only be collected in the cistern. The T_3 is not having any treatment measures and all the runoff is made to collect in the cistern. The three runoff plots for the treatment T_1, T_2 and $T_3$are having an area of 204 m^2. In addition $T_4$and T_5 are also the runoff plots having the individual plot size with an area of 1184 m^2 T_4 and T_5 are constructed with multislot divisors for the collection of runoff. The multi slot divisors are having 15 slots and runoff from one slot is made to pass into the collection cistern. Therefore the total runoff can be worked out by multiplying with 15 for the quantity of runoff collected in the respective plot cisterns. Further the treatment details is as fallows,

T_1: Trenches at 10 m interval at slope 1.7%
T_2: Trenches at 25 m interval at slope 1.93%
T_3: Field conditions at slope 1.9%
T_4: Field condition at slope 2.24%
T_5: Field condition at slope 2.1%

Observation on Runoff and Soil loss

Whenever runoff occurred from the plots, it was collected directly into the cisterns. Total runoff collected in the cisterns is recorded and stirred and representative suspension sample of one litre was collected from each treatment. The water from samples were evaporated in laboratory using hot air oven and silt was weighed for soil loss and interpolated to estimate the total soil loss.

Soil moisture studies

Soil moisture observations were made from the soil samples taken at 0 to 15 cm, 15 to 30 cm and 30 to 45 cm depths, from each plots at 15 days intervals. The soil samples were drawn at three spots, one at the middle and the remaining two samples one each on either side. The moisture content was determined gravimetrically (Reynolds *et al*., 1970) [9].

Results and Discussion

Rainfall

Intensity and duration of rainfall is one of the major inputs to produce runoff. The average annual rainfall of the region is 921 mm. During the period of experimental year 2019, the total rainfall received was 918.1. Monthly rainfall of 173.4, 186.6, 234 and 10 mm recorded for the month of August, September, October and November respectively. In general there are 8, 6 and 5 runoff causing rainfall events recorded for the month of October, September and August respectively (Table 1).

Runoff and Soil loss

Intensity and duration of rainfall is one of the major inputs to induce runoff. During the experimental period, the treatment T_1 resulted in lowest runoff (151.09 mm) and soil loss (3011.67 kg ha^{-1}) from among the treatment. This may be due to the treatment effect of closer trenches at10 m interval which resulted in breaking continuous slopes, reducing the runoff and conserving the rain water in the field itself resulting in higher moisture content. In contrast, the highest runoff was observed in T_4 (230.42 mm) with soil loss of 4218 kg ha^{-1} having the highest field slope of 2.40%. The reason for higher amount of runoff and soil loss may be attributed to the higher slopes. Further, the data also explains that the soil loss was more with the intense rainfall during the experimental period. The reduced trend of the runoff and soil loss was in the order of $T_1<T_2<T_3<T_5<T_4$. The results are presented in table-2. The result are in agreement with those of Manivannan *et al*. (2007) [6].

Impact of contour trenches on soil moisture studies

Observations on soil moisture were recorded at bi-weekly intervals from each runoff plots at 0 to 15 cm, 15 to 30 cm and 30 to 45 cm depths. Observations revealed definite relationship with different treatments and varying slopes and the data presented in the Table 3, Table 4 and Table 5. Soil moisture mainly varied due to the treatment effect of contour trenches and also due to varying slopes. The results of soil moisture indicated that there was difference in the soil moisture percentage among different treatments with varying slopes at different depths. Moisture conserved was higher in contour trenches at 10 m interval and also at different depths during the experimental period, compared to contour trenches at 25 m intervals. The soil moisture trend is in the order $T_1>T_2>T_3>T_5>T_4$ for different treatments. The results are in agreement with the findings of Patode *et al.* (2017) [7]

Influence of contour trenches with different spacing and land slope on the productivity of finger millet crop.

The grain yield for different treatments is presented in table. T_1 (Contour trenches at 10 m interval with slope 1.7 per cent) recorded higher grain yield of 2512 kg ha^{-1}, straw yield of (3768 kg ha^{-1}) and it resulted in economics net returns: 53923; B:C ratio: 3.09 compared to all other treatments. The lower yield was found in T_4 grain yield: 1865 kg ha^{-1}, straw yield: 2687 kg ha^{-1} and the economics of net returns of 35576 and B:C ratio: 2.51. There was an increase in grain yield by almost 34 per cent in T_1 over T_4. The increasing pattern is in the order $T_1>T_2>T_3>T_5>T_4$. The reason for higher grain yield, straw yield and economics was due to more availability of soil moisture compared to other treatments. The results are presented in table-6. The results are in agreement with those of Alloli *et al*. (2007) [2]

Table 1: Rainfall (mm) received during the experimental period of 2019 (Bangalore)

Date	August	September	October	November
1	0	0	-	0
2	0	0	26.20*	0
3	0	0	12.40*	0
4	0	0	17.20*	0
5	0.40	2.40	16.60*	0
6	0.80	0	3.80	0
7	2.20	3.00	-	0
9	6.80	0	-	0.40
10	4.20	0	35.20*	0
11	1.00	0	28.80*	0
12	-	0	3.40	0
13	4.00	2.00	0	0
14	1.40	0	0	0
15	8.80	0	4.40	0
16	24.60*	2.00	0	1.40
17	0	0	0	0
18	1.60	6.40	0	0
19	14.20*	-	1.00	0
20	23.40*	71.20*	3.80	0
21	35.40*	0.80	5.00	0
22	14.80*	0	2.20	8.20
23	0	6.20	33.40*	0
24	1.40	28.40*	1.80	0
25	3.80	26.40*	0	0
26	0	20.40*	0	0
27	0.60	7.60*	0.80	0
28	0	0	1.00	0
29	0	9.80	33.20*	0
30	0	0	0	0
31	24.00*	0	1.80	0
32	0	0	2.00	0
Total	173.40	186.60	234.00	10.00

*Rainfall which caused runoff.

Table 2: Soil loss (tonnes/ha) through the runoff (mm) water during the experimental period of 2019.

Date	Rainfall (mm)	T_1		T_2		T_3		T_4		T_5	
		Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss	Runoff	Soil loss
15-08-2019	24.6	9.92	0.176	10.82	0.179	11.72	0.195	13.30	0.222	12.32	0.210
18-08-2019	14.2	1.80	0.066	2.25	0.070	4.50	0.085	6.96	0.113	5.36	0.098
19-08-2019	23.4	4.50	0.163	4.96	0.170	6.31	0.190	10.07	0.219	10.71	0.209
20-08-2019	35.4	12.17	0.228	12.62	0.239	14.43	0.259	15.58	0.293	14.12	0.270
21-08-2019	14.8	4.50	0.071	2.70	0.085	4.50	0.098	5.85	0.125	5.15	0.103
30-08-2019	24.0	10.82	0.152	12.62	0.162	10.82	0.176	12.56	0.202	11.02	0.182
19-09-2019	71.2	43.29	0.297	43.74	0.366	44.64	0.386	47.05	0.428	46.86	0.399
23-09-2019	28.4	8.11	0.183	5.41	0.191	12.17	0.202	15.09	0.237	14.81	0.211
24-09-2019	26.4	1.80	0.167	3.60	0.186	4.50	0.213	5.88	0.249	5.32	0.219
25-09-2019	20.4	4.50	0.139	4.96	0.145	6.31	0.163	9.86	0.200	8.74	0.171
26-09-2019	7.6	0	0	0	0	2.70	0.034	3.80	0.081	3.34	0.061
02-10-2019	26.2	2.25	0.175	2.70	0.198	3.60	0.211	6.08	0.250	5.82	0.235
03-10-2019	12.4	1.35	0.062	1.35	0.075	2.25	0.087	3.12	0.108	2.97	0.094
04-10-2019	17.2	2.70	0.120	2.70	0.136	4.50	0.142	6.66	0.183	5.85	0.160
05-10-2019	16.6	1.80	0.117	3.15	0.129	4.50	0.138	5.79	0.175	5.07	0.157
09-10-2019	35.2	12.17	0.209	12.62	0.224	14.43	0.239	16.03	0.270	15.35	0.252
10-10-2019	28.8	18.03	0.198	18.94	0.211	24.35	0.225	26.15	0.257	25.84	0.237
22-10-2019	33.4	5.41	0.247	5.86	0.261	8.11	0.284	10.78	0.317	10.12	0.303
28-10-2019	33.2	5.86	0.234	4.96	0.248	7.21	0.256	9.81	0.289	9.07	0.269
Total	493.4	150.98	3.011	156.03	3.277	191.66	3.584	230.43	4.218	217.83	3.841

Table 3: Soil moisture (%) at 0-15 cm depth during the experimental period of 2019

Treatments	Soil moisture (%)							
	Aug		Sept		Oct		Nov	
	15th	30th	15th	30th	15th	30th	15th	30th
T_1	12.70	19.80	13.60	24.90	24.80	22.03	4.87	6.20
T_2	12.20	19.00	12.80	23.80	23.40	22.10	4.80	5.74
T_3	9.80	15.82	11.20	19.50	22.80	17.20	4.50	5.90
T_4	8.90	14.03	10.10	17.80	20.10	14.10	3.32	4.37
T_5	9.30	15.12	10.60	18.42	21.60	15.40	3.98	5.01

Table 4: Soil moisture (%) at 15-30 cm depth during the experimental period of 2019

Treatments	Soil moisture (%)							
	Aug		Sept		Oct		Nov	
	15th	30th	15th	30th	15th	30th	15th	30th
T_1	12.50	18.80	13.86	25.40	24.30	23.90	5.12	6.23
T_2	11.20	18.70	13.01	24.50	22.98	23.85	4.95	5.90
T_3	9.54	14.80	11.87	20.80	21.56	17.80	4.75	5.50
T_4	8.14	12.74	10.33	18.20	19.87	14.90	3.25	4.20
T_5	9.01	14.02	10.84	19.58	20.92	16.10	3.89	4.98

Table 5: Soil moisture (%) at 30-45 cm depth during the experimental period of 2019

Treatments	Soil moisture (%)							
	Aug		Sept		Oct		Nov	
	15th	30th	15th	30th	15th	30th	15th	30th
T_1	11.90	19.50	14.32	28.20	25.60	25.80	5.34	6.54
T_2	11.10	19.00	13.47	26.40	23.12	24.37	4.65	5.95
T_3	9.03	13.98	12.03	22.40	22.48	19.10	5.10	6.12
T_4	8.01	12.46	10.97	18.40	20.56	15.80	2.89	3.37
T_5	8.99	13.13	11.01	20.47	21.48	17.80	3.90	4.88

Table 6: Influence of contour trenches of different spacing and slope on finger millet yield and economics (Rs. ha^{-1})

Treatment	Grain Yield (kg/ha)	Straw yield (kg/ha)	Net Returns (Rs. ha^{-1})	B:C
T_1	2512	3768	53923	3.09
T_2	2325	3425	49305	3.01
T_3	2145	3145	44485	2.89
T_4	1865	2687	35576	2.51
T_5	1987	2781	39455	2.68

Conclusions

The rainfall had much influence on the runoff and soil loss. Contour trenches helps in reducing the flow of runoff which readily increases in conserving soil moisture content. Accordingly the treatment T_1 (trenches at 10 m closer interval) helped to retain the moisture in the field by reducing the runoff and soil loss. Whereas with the same amount of rainfall, It was observed higher runoff and soil loss for the T_4 plot having the slope of 2.4 percent.

On the contrary lower amount of rainfall with very low intensity had not produced runoff and soil loss in lower slopes plots. Also the control measures play an important role in reducing runoff and helps in deep percolation. Accordingly, treatment T_1 is having trenches at 10 m interval resulted in more conservation of rain water which helps in increased deep percolation. The treatments $T_{3,}$ T_4 and T_5 did not have any conservation measures and resulted in higher runoff. T_1 also showed increased productivity in terms of grain and straw yield which resulted in increase of net returns and B:C ratio.

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