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Impact of vegetative barriers on runoff, soil moisture and crop productivity in eastern dry zone of Karnataka

Shivaraj Balooragi, HG Ashoka, K Devaraja, MN Thimmegowda and Murukannappa

Abstract
An experiment was conducted during the *Kharif* season 2021 to evaluate the effect of vegetative barriers namely Nase grass (*Pennisetum hohenackeri*) and Khus grass (*Vetiveria zizanioides*) on runoff, soil moisture and crop productivity at the All India Coordinated Research Project on Dry land Agriculture (AICRPDA), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru. The vegetative barriers were grown at the centre of each plot across the slope as an inter terrace management along with the conservation furrows. During *kharif* season pigeon pea crop was grown in all the plots with conservation furrow. The runoff was significantly reduced under the vegetative barriers as compared with control (without vegetative barrier). Among the two different vegetative barriers, Nase grass (*Pennisetum hohenackeri*) was found to be most effective in controlling runoff and conserving soil moisture. The average runoff generated through the Nase grass and Khus grass was 8.34% and 10.57% respectively, than the control of 12.34%. Similarly, the highest moisture was conserved at Nase grass followed by Khus grass and control was found to be 15.28% and 13.86% and 12.08% at 30 cm depth respectively. During *kharif* season, among two different vegetative barriers, Nase grass proved best followed by Khus grass and control in terms of yield and economics of Pigeon pea. The yield of Pigeon pea in Nase grass was found to be higher (1550 kg ha^{-1}) as compared to Khus grass (1435 kg ha^{-1}) and control treatment (1256 kg ha^{-1}).

Keywords: Runoff, soil moisture, vegetative barriers, economics, yield

1. Introduction

Land degradation is commonly acknowledged to be a major issue. In India, 187.8 million acres (about 57% of the geographical area) is degraded under various forms of degradation (Sehgal and Abrol 1994) [18]. Water-induced soil erosion is the primary driver of land degradation and diminishing soil productivity. It has been estimated that a total of 5,334 million tonnes of soil is lost every year and it is estimated at the rate of 16.4 t ha^{-1} $year^{-1}$ (Narayana and Ram 1983) [7]. This scenario requires for rainwater conservation, erosion protection for cropping lands and for the increased and sustained crop yield.

Mechanical measures control runoff and minimise soil loss by dissipating the energy of flowing water and reducing the length and/or degree of slope (Sharda *et al*., 2002) [17]. Bunding is a mechanical measure that is commonly recommended for controlling soil erosion and conserving moisture in arable land with a 1-6% slope (Singh *et al*., 1990) [15]. However, bunding is not permitted in sandy or sandy loam soils, due to breaching caused by runoff water pressure. Furthermore, they are expensive. Hence, the vegetative barriers are alternative measures to conserve soil and water effectively by moderating surface runoff and allowing for increased infiltration time (Krishnagowda *et al*., 1990) [4]. Vegetative barriers are narrow strips (2-3 feet wide) of stiff, erect densely growing plants, usually grasses, planted across the slope perpendicular to the dominant slope. Because of their dense concentration of thick stems, vegetative barriers slow down the movement of runoff and causing sediment to deposit behind them (Ramajayam *et al*., 2007) [12]. Furthermore, Ranade *et al*. (1995) [13] found that both mechanical and vegetative barriers were effective at reducing runoff by 18-24% on mild slopes.

According to Kumar (2002) [2], the influence of various soil and water conservation (SWC) measures, such as contour bunding, terracing, land levelling, smoothening, and gully plugging, as well as sowing across slopes and vegetative barriers, increased *kharif* crops by 25–30%. In comparison to the conventional way (9.64 t ha^{-1}), the establishment of a vegetative barrier with mechanical measures were more effective in reducing soil erosion (3.8 t ha^{-1}) and controlling runoff, which increased the amount of moisture available for crop development.

Dichanthium annulatum grass was tested for effectiveness in water courses at 2% land slope with various grass coverage and flow rates by Rao *et al*. (2015) [14]. They found that this grass might be used as an efficient filter material to stop runoff and soil loss from crop fields. Sambusta (a native grass) planted on trench-cum bund produced the lowest runoff (9.8%) and soil loss (5.5 t ha^{-1}) compared to other vegetative barriers by Dass *et al*. (2011) [2]. According to Sudhishri *et al*. (2008) [19], sambusta grass at an 11% slope reduced runoff and soil loss by 63.4% and 68.6%, respectively, compared to the control, which had runoff of 25.9% and soil loss of 14.0 t ha^{-1}. Additionally, the finger millet yield inside the plot between the vegetative barriers rose as a result of this vegetative barrier. Impact of different SWC measures including agronomical and engineering measures on runoff, soil loss and productivity of crops have also been done by several other researchers (Behera *et al*., 2014; Naik *et al*., 2014; Kumar *et al*. (2021); Panigrahi, B. 2007; Panigrahi, 2008; Singh and Khera, 2006) [1, 6, 3, 8, 9, 16].

In order to prevent soil and water erosion, SWC techniques, including both agronomical and engineering measures, are now being used in diverse places. This is revealed by a study of prior research studies conducted elsewhere in the nation and abroad. However, because they are site-specific and reliant on particular local soil and management circumstances, these conservation strategies cannot be utilised entirely in other places. Eastern Dry Zone of Karnataka receives medium to high rainfall ranges from 679.1 mm to 888.9 mm with an area of 1.808 Mha. During *Kharif* season more than 50% of annual rainfall receives in the regions of red loamy and lateritic soils. Therefore, this experiment has been carried out with objectives to quantify the effect of vegetative barriers on runoff, moisture conservation and productivity of pigeon pea crop in Eastern Dry Zone of Karnataka.

2. Materials and Methods

2.1 Study Site

The present study was conducted at the All India Coordinated Research Project on Dry land Agriculture, University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru and it is located at $12^0 58'$ North latitude and 77^0 35' East longitude with an altitude of 924 meters above mean sea level. The experimental site comes under Eastern Dry Zone of Karnataka. The monthly meteorological data for the year 2021 and the normal for the past 29 years (1992-2021) were recorded at the meteorological observatory of the All India Coordinated Research Project on Agrometeorology, Gandhi Krishi Vignana Kendra, Bengaluru.

2.2 Climatic condition

The total actual rainfall received during the year 2021 was 1328.4 mm as against the normal rain fall of 954.7 mm, hence 373.7 mm is excess than the normal rainfall. However, the rainfall recorded during crop growth period varies. The rainfall was lower than the normal in the months of March (-17.6 mm), May (-90.5 mm), August (-24.4 mm) and September (-16.4 mm). While it was higher than the in the months of January (9.7 mm), February (30.4 mm), April (5.2 mm), June (36.5 mm), July (68.6 mm), October (58.6 mm), November (305.7 mm) and December (7.8 mm). It was observed that 56 normal rainy days as against to the actual rainy day during 2021 is 82. The maximum temperature of the area goes up to 33.5 °C in April and the minimum goes up to 14.6 °C in February. The soil of experimental site was red sandy clay loam in texture. The soil was deep and possess good drainage. The soil of experimental site was slightly acidic in reaction (5.60).

2.3 Experimental Plots

Three experimental plots were laid with the total area of 17,490 m^2 as shown in Fig. 1. At the lower end of each plot farm ponds were dug for the purpose to collect runoff from experimental plots. The runoff collected in each pond is estimated through prismoidal formulae. The runoff water overflow through the H-flume is estimated by analysing the hydro-graph of stage level recorder. The vegetative barriers/grasses as inter terrace management, were grown on bunds at a centre of the experimental plots across the slope. Two vegetative barriers/grasses, *viz,* Vetivar (*Vetiveria zizanioides*) grass and Nase (*Pennisetum hohenackeri*) grass were tested for their effectiveness in controlling runoff and conserving soil moisture and consequently the effect on the crop yield of pigeon pea (BRG 5). The results from these two experimental plots were compared with the control experimental plot where no vegetative barrier was planted.

2.4 Data Collection

For the runoff studies, daily rainfall data was collected from the nearby rain-gauge installed at the Dry Land Agriculture Project (DLAP), UAS, GKVK, Bangalore. Runoff from the experimental plots were measured after each rainstorm by measuring the difference in the volume of farm pond before and after the occurrence of rainfall. For measurement of soil moisture, soil samples were collected at 15 cm and 30 cm depth on monthly interval basis during cropping period (2021).

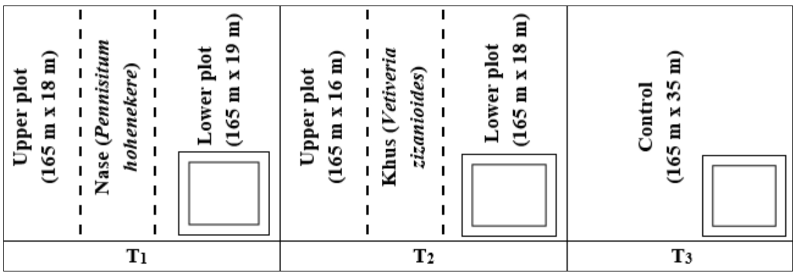

Fig 1: Plan of layout of experimental site

2.5 Statistical Analysis

The statistical analysis of the recorded data and effect of vegetative barrier on moisture and crop yield were recorded from all the treatments, was carried out as per the ANOVA procedures of randomized complete block design. Differences between individual means were compared at 5% level of significance.

3. Results and Discussion

3.1 Rainfall-Runoff Analysis

The annual rainfall during the year 2021 was 1328.4 mm with 82 rainy days, whereas normal annual rainfall in the region is 954.7 mm. The amount of rainfall received during the cropping period (June to December) was 1190.6 mm with 74 rainy days as shown in (Table 1). The highest and lowest rainfall recorded during cropping period was 367.4 mm in the month of November with 16 rainy days. And the lowest rainfall recorded during cropping period was in 20.2 mm in the month of December with 2 rainy days. The highest runoff recorded was 12.34% during 2021. The amount of runoff generated depends not only on the amount of rainfall but also on the intensity of rainfall and the antecedent moisture content of the soil.

Table 1: Monthly Rainfall and Rainfall Events during the Cropping Period (2021)

Month	Rainfall(mm)	Rainfall events
June	117.6	9
July	171.6	13
August	115.4	10
September	166.8	8
October	231.6	16
November	367.4	16
December	20.2	2
Total	1190.6	74

3.2 Effect of vegetative barriers on runoff

The runoff was low in the plots where vegetative barriers were established as compared to the control plot during the cropping period (2021). Vegetative barriers not only slow down the movement of water thus giving more time for infiltration of water into the soil, but also their roots have soil binding properties which reduces the soil loss and runoff (Dass *et al*., 2011; Thakur *et al*., 2013) [2, 20]. The effect of different vegetative barriers on the runoff from the experimental plots is given in Table 2 and 3. Among the two vegetative barriers, the highest runoff of 102.70 mm was observed under Khus (*Vetiveria zizanioides*) grass, whereas the lowest runoff of 81.08 mm was recorded under the Nase (*Pennisetum hohenekere*) grass. The average runoff generated through the Nase grass and Khus grass were 8.34% and 10.57% respectively, when compared to control with the runoff of 12.34%. The higher effectiveness of Nase grass and Khus grass is due to the bushy growth of the grasses. These grasses do not allow the runoff to easily pass through them and hence provide more infiltration opportunity time to the runoff water and Nase grass was more superior when compared to Khus grass and control (Ramachandrappa *et al*., 2014) [11].

Table 2: The effect of different vegetative barriers on the runoff (mm) during the Cropping Period (2021)

Month	Runoff (mm)		
	Pond 1 (Nase)	Pond 2 (Khus)	Pond 3 (Control)
June	2.56	3.20	4.97
July	4.32	5.71	9.22
August	2.05	2.73	4.18
September	10.40	16.74	19.49
October	15.11	21.53	25.49
November	46.46	52.58	57.57
December	0.18	0.22	0.34
Total	81.08	102.70	121.23

Table 3: The effect of different vegetative barriers on the runoff (%) during the Cropping Period (2021)

Month	Runoff (%)		
	Pond 1 (Nase)	Pond 2 (Khus)	Pond 3 (Control)
June	3.18	3.97	5.46
July	3.22	4.25	6.87
August	3.06	4.07	6.23
September	7.16	11.53	13.42
October	7.80	11.11	13.15
November	13.71	15.52	16.99
December	1.47	1.74	2.71
Total	8.34	10.57	12.34

3.3 Effect of vegetative barriers on Soil moisture

Soil moisture content measured by gravimetric method at the monthly interval and most critical stage of the test crop (flowering) at 15 cm and 30 cm depth of soil and the results were presented in Table 4 and 5. Nase and Khus grass barrier treated plots retained 13.16% and 12.07% higher moisture, respectively, over the control plots of 10.42% at 15cm depth. Among the vegetative barriers, the Nase grass treated plots (15.28%) had the highest moisture content compared to Khus grass plots (13.86%). The control plot shows the lesser moisture of 12.08% at 30 cm depth compared with the plots with vegetative barriers. The higher moisture content exhibited by the Nase treated plots is due to higher conservation and less runoff of rain which was infiltrated into the soil. The findings are in line with the observation of Patil *et al*. (1995) [10] and they observed 16% higher soil moisture in the sorghum cropped plots provided with vetiver barrier as compared to control.

Table 4: Effect of vegetative barriers on Soil moisture at 0-15 cm depth during the Cropping Period (2021)

Treatments		August	September	October	November	December	Mean
T1	Nase Upper	9.60	12.56	13.21	14.38	10.70	12.09
	Nase Lower	10.8	15.65	15.11	16.7	12.84	14.22
	Mean	10.20	14.11	14.16	15.54	11.77	13.16
T2	Khus Upper	8.89	11.54	12.3	13.48	9.90	11.22
	Khus Lower	9.58	13.98	14.02	15.19	11.83	12.92
	Mean	9.24	12.76	13.16	14.34	10.87	12.07
T3	Control	7.98	10.86	11.45	12.53	9.26	10.42

Table 5: Effect of vegetative barriers on Soil moisture at 15-30 cm depth during the Cropping Period (2021)

Treatments		August	September	October	November	December	Mean
T1	Nase Upper	11.00	14.90	15.44	17.55	11.94	14.17
	Nase Lower	12.58	17.40	18.45	19.32	14.25	16.40
	Mean	11.79	16.15	16.95	18.44	13.10	15.28
T2	Khus Upper	10.41	14.27	14.48	15.62	11.63	13.28
	Khus Lower	11.13	15.27	15.97	16.85	12.98	14.44
	Mean	10.77	14.77	15.23	16.24	12.31	13.86
T3	Control	9.52	12.45	13.28	14.6	10.54	12.08

3.4 Effect of vegetative barriers on Yield and Economics

Crop grain yield

The grain yield of the Pigeon pea crop under vegetative barriers was significantly higher than that under control plots during *Kharif* season 2021 as indicated in Table 6. The highest grain yield was obtained under Nase grass and was significantly higher than Khus vegetative barrier. The lowest grain yield was found in case of control treatment. The highest grain yield of Pigeon pea in Nase grass vegetative barrier plot was 1550 kg ha^{-1} as compared to Khus grass plot and control treatment was found to be 1435 kg ha^{-1} and 1256 kg ha^{-1} respectively. The reason for effectiveness of Nase grass and Khus grass when compared to control may be due to the less runoff and higher retention of moisture in the experimental plots planted with these grasses. The statistical analysis of the data showed that there is significant difference in means of yield among the different vegetative barrier treatments during the *kharif* season at 5% level of significance.

Table 6: Effect of vegetative barriers on Yield and Economics of pigeon pea crop

Treatments		Grain Yield (Kg ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	B:C ratio
T1	Nase Upper	1433	71648	36143	2.02
	Nase Lower	1666	83319	47814	2.35
	Mean	1550	77484	41978	2.18
T2	Khus Upper	1353	67645	32140	1.91
	Khus Lower	1518	75900	40395	2.14
	Mean	1435	71772	36267	2.02
T3	Control	1256	62823	27318	1.77

3.5 Economics

The B:C ratio was calculated by taking into account the cost factor under treatments, total net benefits from crops and vegetative barriers. The highest B:C ratio of 2.18 was recorded in Nase vegetative barrier plot as compared to Khus grass plot (2.02) and control (1.77) respectively as presented in (Table 6).

4. Conclusions

From the study, it can be concluded that the vegetative barriers are very effective in controlling runoff and conserving soil moisture and also in increasing the crop yield. Farmers can easily adopt vegetative barriers because they are a low-cost technology. Nase grass vegetative barrier was found to be the most effective in controlling runoff and conserving soil moisture among the two vegetative barriers tested. The lowest runoff was recorded in Nase grass (8.34%), in comparison to the Khus grass vegetative barrier (10.57%) and the control (12.34%). During the *kharif* season (2021), the yield (1550 kg ha^{-1}) of the Pigeon pea crop and soil moisture (18.44%) conserved were highest in the Nase grass, followed by the Khus grass vegetative barrier and the control plot. Thus, the establishment of vegetative barriers should be encouraged in order to reduce runoff and soil loss while increasing crop productivity.

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