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COMPARATIVE EFFECT OF *SACCHARUM BENGALENSE* RETZ. AND *VETIVER ZIZANIOIDES* (L.) NASH ON SURFACE RUNOFF AND SEDIMENT LOSS AT VARYING SLOPE GRADIENTS

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Abstract: The current study was conducted to evaluate the effectiveness of two plant species i.e. *Vetiver zizanioid* (Vetiver grass) and *Saccharum bengalense* Retz (Munj sweetcane) to reduce soil losses on the slopes. In this study two sets of 6 plots of 5 m × 2 m with their long axis oriented upslope were developed. The first set consisted of two plots under each of 1%, 5% and 10% slope gradient, While, the second set of plots consisted of two plots under each 15%, 20% and 25% slope gradients. It was evident that survival rate of *V. zizanioides* (L.) Nash was much higher (above 90%) as compared to Munj sweetcane. The analysis of data suggested that *V. zizanioides* (L.) Nash mediated about 50% reduction in runoff as compared to situation without any vegetative cover. In conclusion, *V. zizanioides* (L.) Nash can be effectively used to reduce soil losses on inclined surfaces.

Keywords: *Saccharum bengalense* Retz., surface runoff, soil losses, sediment losses, vegetative cover, *Vetiver zizanioides* (L.) Nash

Introduction

Soil erosion is a significant concern when considering regional ecological resource protection (Ouyang et al., 2010). It is a major cause of soil degradation that removes fertile topsoil besides causing land sliding on steep slopes. The United Nations Food and Agriculture Organization (FAO) declared soil erosion as one of the important social, economic and ecological problems, seriously threatening land-use sustainability in China (FAO, 2004). As far as the magnitude of soil erosion is concerned, any soil loss of more than 1 t ha^{-1} $year^{-1}$ can be considered as irreversible within a time span of 50 –100 years (EEA, 1999). Rainfall intensity, being major agent of soil erosion has close relationship with angle of slope, soil texture and type of cover. Soil erosion and water loss hazards in rain fed areas are very severe. Nearly 76% of the total area of Pakistan is subjected to erosion in one form or the other. Out of which, water erosion is active on 60% and wind erosion on 40 % (www.fao.org). Though the erosion is a geological process, it has become a serious problem during the recent years due to mismanagement of the land. Soil erosion also causes siltation in water reservoirs and rivers which reduces their capabilities and results in flood hazards.

Soil erosion and sediment yield is prevalent in many regions of the world (Ouyang et al., 2010). Recent urbanization has aggravated the intensity of this problem. A number of serious aggravating factors contribute to this soil erosion problem including hilly topography, erosion-prone soil properties, land cover conditions, climate and inappropriate agricultural practices (Irvema et al., 2007; Hessel and Jetten, 2007). The factors affecting runoff may be divided into those factors associated with the precipitation (duration, intensity, amount, distribution) and those associated with the water shed (size, Shape, orientation, topography, geology and surface cover) (Shafiq *et al.*, 1987). Thus if there is variation between rainfall and catchment characteristics, there will be variation to a great extend in runoff and soil loss (Shafiq *et al.*, 1987). Rowlison and Martin (1971) concluded that the slope was a major factor in soil particles detachment and surface runoff. Morgan (1988) and Shafiq et al. (1988 and 2001) observed an increased surface runoff and soil loss with the increase of surface gradient and length of run. Increased soil erosion may be attributed to increase in velocity and volume of surface runoff.

Vegetation plays the major role to curtail the process of erosion on gullied areas and steep slopes. The effectiveness of plant cover in reducing soil

erosion depends upon the height and continuity of the canopy; the density of ground cover and root density (Morgan, 1988). According to Singh *et al.* (1991) a dense vegetation cover is most powerful weapon for reducing erosion. The major role of vegetation is to intercept the raindrop so that kinetic energy is dissipated by plants rather than imparted to the soil. Shafiq *et al.* (1994) observed that catchment under gullied if planted with *Leucena lucocephala* (Ipil-Ipil) resulted in zero runoff after 8 year of planting, while *Eucalypts camaldulensis* decreased about 21% runoff as compared to control. The effect of rainfall on bare soil can be reduced with the application of vegetative cover. Previous studies have also confirmed that application of grass is economical and viable solution to bare soil and reduce the effect of soil erosion. The present study was, therefore, aimed to investigate the effect of ground cover on surface runoff and soil loss using tow grasses *V. zizanioides* (L.) Nash and *S. bengalense* Retz. under different slope gradients.

Material and Methods

A field study was conducted during 2007-08 at Mangial in the Fatehjang target area. The study area lies between latitude 33°-30′ to 33°-35′ N and longitude 72°-45′ to 72°-50′ E. Target area is located in the isohyets lines of 750-1000 mm with an average value of 990 mm. About 53% of annual precipitation occurs during monsoon (July-September) season (Shafiq and Ahmad, 2001).

Runoff plots can be used to estimate the surface runoff and soil losses using simplified approaches. The runoff plots are inexpensive and can be constructed easily (Djorovic, 1975). In this study two sets of 6 plots of 5 m × 2 m with their long axis oriented upslope were developed. The first set consisted of two plots under each of 1%, 5% and 10% slope gradient. Whereas, second set of plots consisted of two plots under each 15%, 20% and 25% slope gradients. The plots were separated by a buffer zone of about 60 cm wide, and were demarcated with bricks. The surface runoff was collected in a water tank constructed on the downstream side. One plot under each surface gradient was planted with *V. zizanioides* (L.) Nash sapling. The height of each plant was 6 inches (15 cm) with 12 cm root penetration. Each sapling of plant had 3 slips and planted in diagonal pattern. The other set of plot were planted with *S. bengalensis* with same specifications.

The surface runoff after each runoff event was collected in storage tank and measured. A manually recording rain gauge was installed to measure the rainfall amount. The amount of surface runoff received at each storm was calculated in cm and percentage of runoff/rainfall for a particular rainfall event was calculated with the help of following equation (U.S. Soil Conservation Service, 2010):

$$Runoff\,\% \Rightarrow R = \frac{VRo}{VR} \times 100$$

Where,
R = Runoff
$VRo = d \times a$ (d = depth of runoff in tank,
a = Cross – section area of tank)
$VR = R \times A$ (R = amount of rainfall in mm,
A = Area of plot in m^2)

Water samples from water tanks were collected to record rainfall events for sediment concentration and soil loss estimates. For sediment loss following equation has been followed:-

$$S = \sum_{1-15}^{n} S$$

$$S(i) = VRo(i) \times SS(i)$$

Where,
$S(i)$ = sediments of ith rainfall
$VRo(i)$ = Runoff of ith rainfall
SS = Sediment out of Runoff Sample of ith rainfall

Data thus generated were analyzed statistically with the help of Microsoft EXCELL Sheet for comparing the surface gradient and ground cover conditions on surface runoff and sediment loss.

Results and Discussion

Survival rate of plants

Plants were planted in November, therefore, during initial 6 months; there was a prolonged frost period of almost 3 to 4 months. Consequently, plant growth during that period remained very slow. However, it confirmed fact about *V. zizanioides* (L.) Nash is its survival rate. The Grass is tolerant to extreme climatic variations such as prolonged drought, flood submergence and temperature levels ranging from 20°C to 55°C. *V. zizanioides* (L.) Nash has been found

to thrive under rainfall ranging from 300 mm to 6000 mm per annum. The grass has the ability to re-grow rapidly after being affected by drought, frost, fire, saline and other adverse conditions when the adverse effects are removed (Truong and Baker, 1998). The comparison of survival of both plant species is presented in Fig. 1, where survival rate of *V. zizanioides* (L.) Nash, except 15% slope, remained more than 80%. Whereas, *S. bengalense* Retz. survival rate was less than 50% on high slopes which means plant is not suitable for steep slopes and can only survive on areas with low gradient or plain areas.

Total rainfall during the experimental year (Nov 07-Nov 08) was 577 mm in 15 rainfall events. Out of which 80% was received during summer season (Jun 2008-Sep 2008). During summer, out of 11 rainfall events amounting 458 mm, all events generated runoff. During winter season (Nov 2008 – May 2008), out of 4 events amounting 118.55 mm, all events generated runoff. Rainfall distribution indicated that summer season rainfalls are relatively less variable as compared to winter.

Runoff

Mean annual percentage of runoff, generated by plot using *V. zizanioides* (L.) Nash and *S. bengalense* Retz. were compared. Figure 2 shows the comparative account of average run-off of 15 rainfall events on each slope without any plant cover. Each rainfall event was indicated with letter 'R' (R1-R15). The huge differences in R^2 values ranging from 0.5 to 0.9 for linear relationship between runoff and different slopes might have arisen due to presence of varying degree of vegetation.

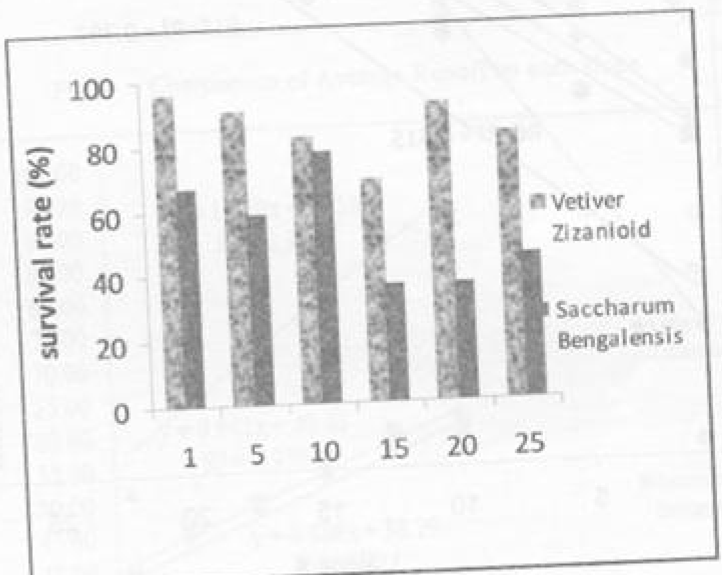

Fig. 1. Comparison of survival rate of grasses.

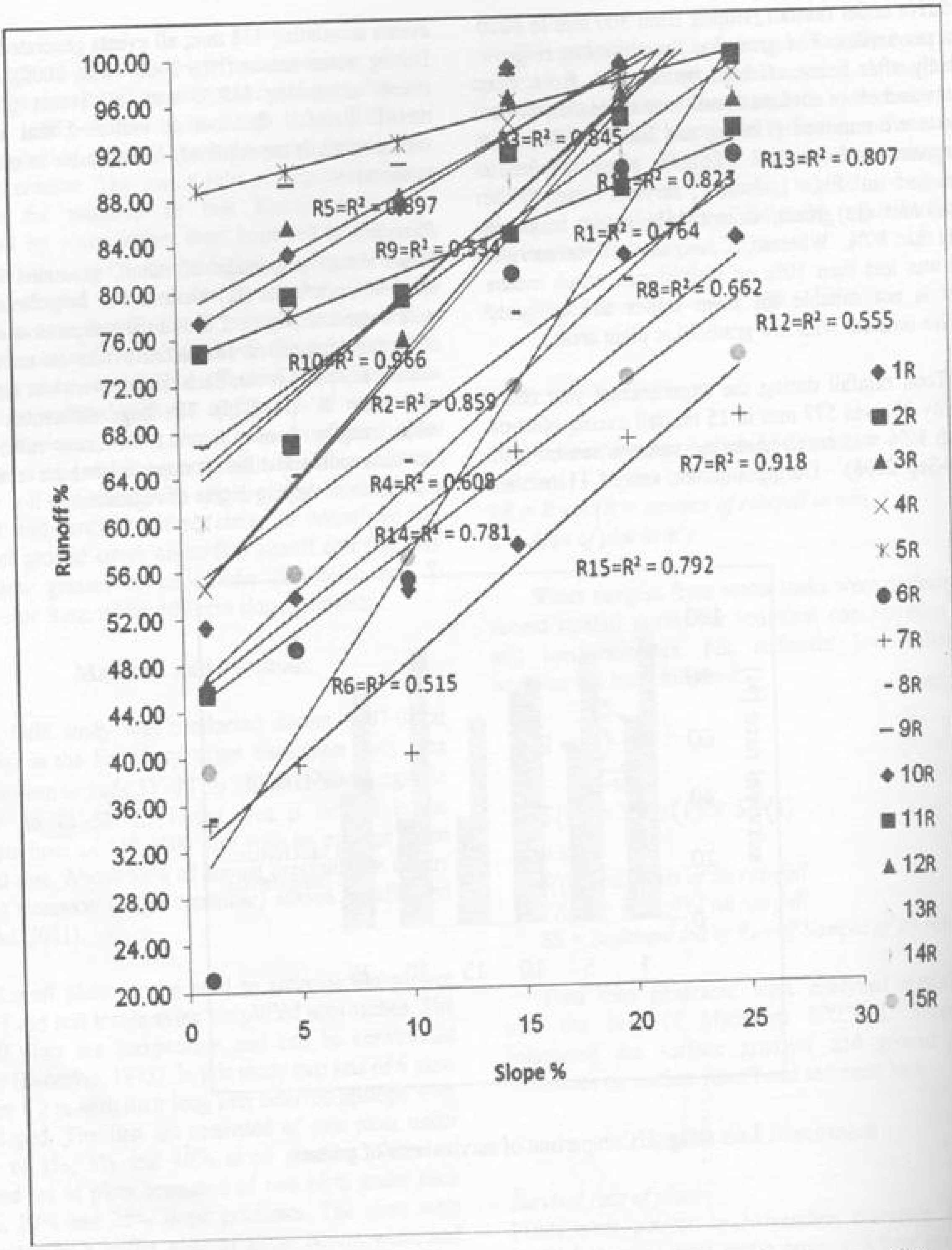

Fig. 2 Runoff under different slope – Plots without vegetation.

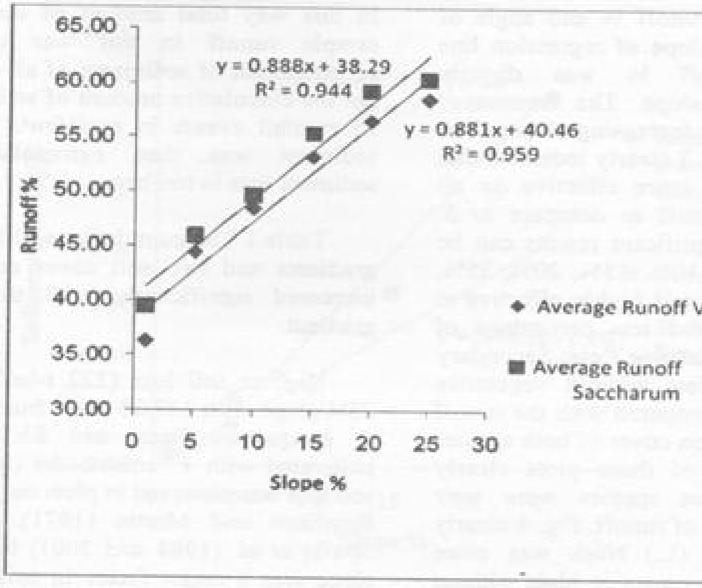

Fig 3. Comparison of Average Runoff on each slope.

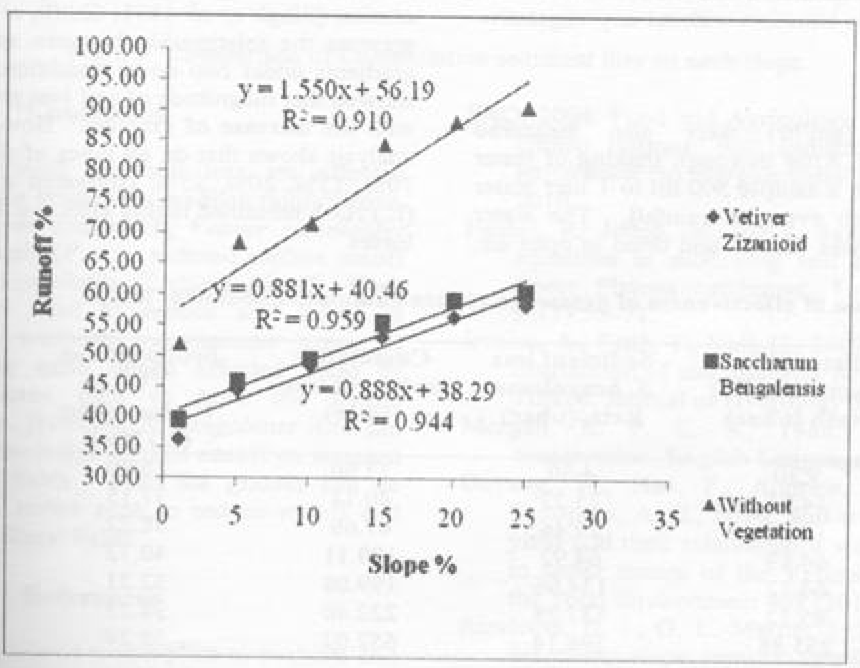

Fig. 4. Comparison of mean runoff with vegetation and without vegetation cover.

Averages of runoff of all events on each slope under each grass i.e. *V. zizanioides* (L.) Nash and *S. bengalensis* have been recorded. The trend lines of all runoff events clearly indicated that there was a strong

positive relationship between runoff % and angle of slope (Fig. 3). R^2 values and slope of regression line again confirmed that runoff % was directly proportional to the angle of slope. The amount of runoff water increases with the increasing slopes. The regression values plotted in Fig. 3 clearly indicated that *V. zizanioides* (L.) Nash was more effective on all slopes, and generated less runoff as compare to *S. bengalense* Retz. But most significant results can be observed on higher slopes i.e. 10%, 15%, 20%, 25%, where *V. zizanioides* (L.) Nash was highly effective in controlling runoff and generated less percentage of runoff as compared to *S. bengalense* Retz. Secondary data of runoff from same plots without vegetative cover was also obtained and compared with the runoff data in the presence of vegetation cover of both species (Fig. 4). Analysis of runoff of these plots clearly indicated that, with the plant species were very affective in reducing the extent of runoff. Fig. 4 clearly indicated that *V. zizanioides* (L.) Nash was more effective to control runoff as compare to plots without vegetative cover. The analysis of data suggested that *V. zizanioides* (L.) Nash mediated about 50% reduction in runoff as compared to situation without any vegetative cover.

Sediment Losses

Sediments losses (gm/ltr) were also measured consequent to runoff. After thorough shaking of water collected in reservoir, a sample 500 ml to 1 liter water was taken, after each event of rainfall. The water sample so collected was filtered and dried in open air. In this way total amount of dissolved sediments i sample runoff in gm was collected. With th accumulation of sediments of all events of rainfall, w got the cumulative amount of sediments lost during a 15 rainfall events in mg/10m². The total amount c sediment was then extrapolated and calculate sediment loss in ton/hec.

Table 1 The cumulative soil loss on different slop gradients and two soil cover conditions. Soil losse increased significantly with the increase in slop gradient.

Highest soil loss (222 $t\text{-}ha^{-1}$) was observed fro 25% slope with 137.23 t ha^{-1} from plots cultivated wit *S. bengalense* Retz. and 85.12 $t\text{-}ha^{-1}$ from plot cultivated with *V. zizanioides* (L.) Nash. The lowe soil loss was observed in plots on 1% slope 13.60 $t\text{-}ha^{-1}$ Rowlison and Martin (1971), Morgan (1988) an Shafiq *et al.* (1988 and 2001) had concluded that th slope was a major factor in soil particles detachmen and transport. Vegetative cover by virtue of absorbin the kinetic energy of falling rain drops reduced soi erosion (Singh *et al.* 1991; Shafiq *et al.* 1994). Fig. presents the relationship between soil loss and slop gradients under two cover conditions. The trend lin showed that magnitude of soil loss gradually increased with the increase of gradient. However, comparativ analysis shows that on all types of slopes i.e. 1%, 5% 10%, 15%, 20%, 25%, cultivated with *V. zizanioide* (L.) Nash remained highly effective to reduce sedimen losses.

Table 1. Comparison of effectiveness of grasses to reduce cumulative sediment losses.

slope%	Sediment loss *V. zizanioides* (L.) Nash (t/hac)	Sediment loss *S. bengalense* Retz. (t/hac)	Cumulative sediment loss (t/hac)	Sediment loss (%) *V. zizanioides* (L.) Nash	Sediment loss (%) *S. bengalense* Retz.
1	9.30	4.30	13.60	18.40	31.60
5	14.91	25.23	40.14	37.15	62.85
10	18.23	29.46	47.69	38.22	61.78
15	64.19	64.92	129.11	49.72	50.28
20	64.12	134.96	199.08	32.21	67.79
25	85.12	137.28	222.40	38.27	61.73
total	255.88	396.14	652.02	39.24	60.76

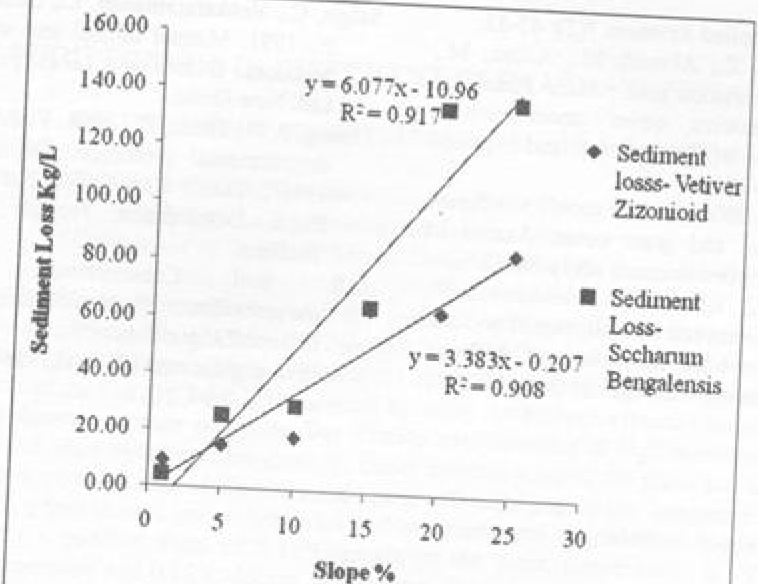

Fig. 5. Comparison of Cummulative sediment loss on each slope.

Conclusion

The surface runoff and soil loss are affected significantly by slope gradient in medium rainfall zone. The vegetative cover comprising *Vetiver zizanioides* (L.) Nash significantly (*P*.....) reduced surface runoff and sediment losses on slopes. *V. zizanioides* (L.) Nash can be effectively used to reduce soil losses in Pothohar Plateau, northern mountainous areas of Pakistan, especially earth quake affected areas of Kashmir and Murree hills to hold the fragile mountainous slopes. However, *S. bengalense* Ritz can also be used to act as hedge against runoff on terraced type of cultivated fields. Both the grasses can be effectively used as buffer zone to reduce runoff and soil losses on agricultural fields.

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