

Measurement of Rainwater Infiltration Capacity of Vetiver Grass Using 1.8 m Plastic Circular Column

Chandrashekhar Bhadsavle, Anil Nivalkar, Parshuram Agivale

Abstract

Heavy rainfall on bare slopes often leads to excessive runoff, soil erosion, and poor groundwater recharge due to limited infiltration. This study investigates the effectiveness of Vetiver grass (*Chrysopogon zizanioides*) in enhancing rainwater infiltration through soil, using a pair of large 1.8 m high soil columns (55 cm diameter) under natural rainfall. One column was planted with vetiver grass, and the other left bare, to compare percolation of rainwater over two monsoon seasons. Results showed a dramatically higher infiltration capacity in the vetiver-planted column; summing all the measurements of 230 rainy days Column A drained **~1467 L** of water (collected percolation) while Column B drained only **~465 L**. In other words, the vetiver column percolated almost **100%** of the incident rainfall (even slightly more in measured total, due to ongoing drainage from large storms), whereas the bare soil column only percolated about **40%** of the rain – the remainder of water in the bare column was not absorbed, leading to surface runoff or retention in the soil. The vetiver column also had no observable surface runoff or soil loss, unlike the bare column which showed sediment build-up from runoff. These findings demonstrate that vetiver's deep root system and ground cover can greatly improve rainwater infiltration and prevent erosion on slopes. The experiment provides quantitative evidence supporting vetiver grass as an effective nature-based solution for enhancing soil infiltration and conserving rainwater in situ on vulnerable slopes.



The water percolation experiment which was in place for more than 400 days (two rainy seasons).

Introduction

Rainfall on exposed slopes often leads to significant surface runoff, causing soil erosion and poor groundwater recharge. Enhancing the soil's infiltration capacity can mitigate these issues by reducing runoff and allowing more rainwater to percolate into the ground. Vegetative measures, especially deep-rooted grasses like vetiver (*Chrysopogon zizanioides*), have been widely recognized as effective, low-cost solutions for soil and water conservation springer.com, vetiver.org. Vetiver grass is a perennial bunchgrass with a massive, fibrous root system that can reach several meters deep, binding the soil and improving its structure. The presence of vetiver vegetation on slopes typically increases soil permeability and infiltration rates, which in turn greatly reduces the volume and velocity of runoff water vetiver.org. Studies have shown that vetiver Live Contour Bunding (LCB) can reduce surface runoff by on the order of 60–70% compared to bare soil conditions springer.com, vetiver.org. This occurs because the dense LCB slow down and spread out flowing water, giving it more time to seep into the soil, and the vetiver root channels provide deep pathways for water infiltration vetiver.org. By the same token, substantially less sediment is lost from vegetated slopes – properly established vetiver strips have been documented to cut soil losses to very low levels (e.g. <3 tons/ha) vetiver.org while also increasing groundwater recharge by creating more infiltration opportunities.

Given these advantages, vetiver grass is often promoted for stabilizing hill slopes and conserving rainfall. However, quantitative field data on how much vetiver can improve infiltration under natural rain conditions are valuable for understanding its impact. This paper presents a controlled experiment measuring rainwater infiltration in soil columns with and without vetiver grass. The objective was to quantify the difference vetiver roots and canopy can make in infiltrating rainwater (and reducing runoff) by simulating a hillside soil profile inside large vertical columns. The study spans two monsoon seasons, providing direct measurements of percolated water (“infiltration”) from a vetiver-planted column versus a bare-soil column, under the same natural rainfall events.



The Live Contour Bunding (LCB) of 3 years on 150 acres area of forest hill

Materials and Methods

Two large plastic drums (each 90 cm in height and 55 cm in diameter) were used to construct a single circular column of 1.8 m height. The drums were stacked vertically and joined to form a continuous tube: the bottom of the top drum and the top of the bottom drum were removed by machine cutting, then the joint was secured to be water-tight using rubber from bicycle inner tubes. This created a cylindrical soil column 1.8 m tall with an open top diameter of 55 cm. Two identical such column setups were prepared (labeled **Column A** and **Column B**):

- **Column A (Vetiver Column):** This column was planted with vetiver grass. A well-established vetiver clump (containing ~15–20 slips of *C. zizanioides*) previously grown in a plastic bag was transplanted into the top of Column A.
- **Column B (Control/Bare Soil Column):** This column had the same soil profile as Column A but **no vegetation** planted on top (bare soil surface).

Both columns were filled with a natural hill slope soil profile to replicate field conditions. Soil was excavated from a nearby hillside in successive layers (to preserve the stratification of topsoil and subsoil). Each layer was kept in labeled bags during transport, then placed into the drums in the same order and thickness as in the original slope, ensuring the column soil profiles closely mimicked the natural layering. The soil was packed into the columns all the way to the top and even slightly above the drum rim, forming a convex “hip” shape mound protruding a bit over the edge (as often seen on natural slopes).

Each column had a drainage outlet at the base to collect infiltrated water. At the bottom of both Column A and B, a circular section (~28 cm diameter) of the plastic wall was cut open. This allowed any water percolating through the soil profile to drip out of the column base. A 20 L capacity plastic bucket was placed directly underneath each column to catch the percolating water. The columns were mounted on sturdy brick-and-cement stands in an upright position, elevated enough so that the collection buckets could be slid underneath the open bottoms. All joints and interfaces were checked to ensure no lateral leakage of water – the only exit for water was through the bottom opening into the buckets.

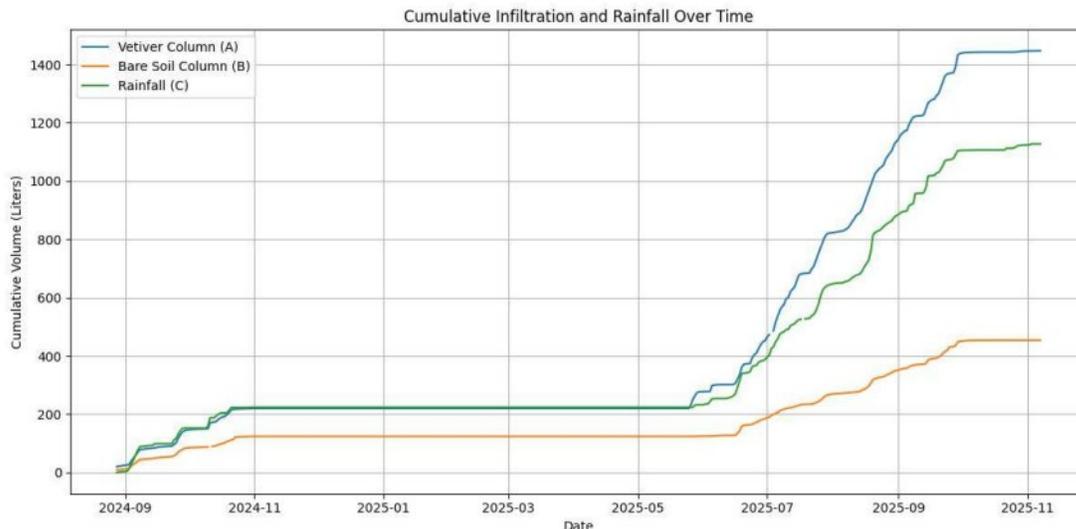
In addition to the two soil columns, a third drum (**Column C**) was set up as a rain gauge to measure the actual rainfall input. This was a single plastic drum identical in diameter (55 cm open top) to the others, but with no soil – it was just left open to directly collect rainwater. Column C thus provided the reference for how much rainwater fell (volume captured in 24 hours) on the same catchment area as the soil columns’ top surface area.

The experiment was conducted in an outdoor environment (open air) to expose the columns to natural rainfall. It began in late August 2024 and continued through the end of the 2025 monsoon. A total of two rainy seasons were observed: the latter part of the 2024 monsoon (late August to October 2024) and the full 2025 monsoon (late May to early November 2025). During the intervening dry season (November 2024–April 2025), there was essentially no rainfall and thus no data (the columns were left in place, and measurements resumed when rains began in 2025).

Measurement procedure: Throughout the rainy periods, the water collected in the buckets under Column A, Column B, and the rainfall drum (Column C) was measured every 24 hours. Each day (typically each morning) the buckets were removed and the volume of water was measured using a graduated measuring beaker (in liters). After measuring, the buckets were emptied and placed back under the columns. On days of very heavy rainfall, measurements were conducted **twice a day** (morning and evening) to avoid the buckets overflowing – in such cases the two readings would be summed for the 24-hour total. All measurements (daily percolation from Column A and B, and rainfall caught by Column C) were recorded in an Excel sheet along with the date. In total, **230 rainy-day observations** were logged over the course of the experiment.

Observations and Results

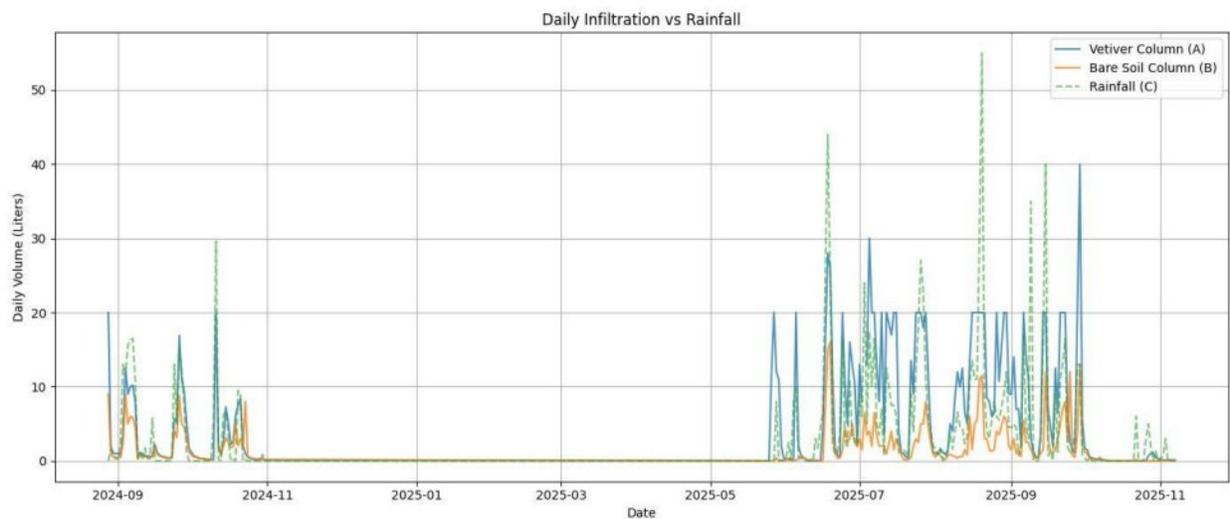
Rainfall and infiltration volumes: Over the two monsoon seasons observed, the open-top rain gauge (Column C) recorded a cumulative rainfall of approximately **1127 L** falling onto the 55 cm diameter area (this is roughly equivalent to 4700 mm of rain in total). The presence of vetiver had a dramatic effect on infiltration of this rainwater. **Column A (vetiver-planted)** allowed nearly all of the rain to infiltrate through the soil, whereas **Column B (bare soil)** only infiltrated a fraction of the rain. Summing all measurements, Column A drained **~1467 L** of water (collected percolation) while Column B drained only **~465 L**. In other words, the vetiver column percolated almost **100%** of the incident rainfall (even slightly more in measured total, due to ongoing drainage from large storms), whereas the bare soil column only percolated about **40%** of the rain – the remainder of water in the bare column was not absorbed, leading to surface runoff or retention in the soil. This striking difference was consistent throughout the experiment, becoming even more pronounced in the second year as the vetiver root system grew more extensive.



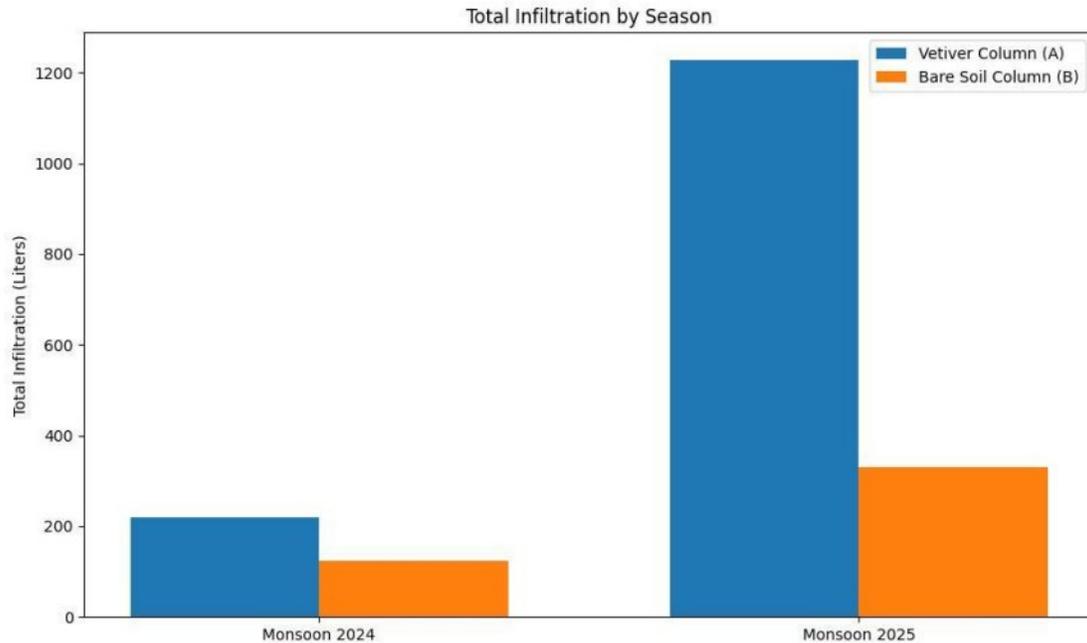
Cumulative rainfall vs. cumulative water drained in the vetiver column (A) and bare soil column (B) over time (Aug 2024 – Nov 2025). The vetiver-planted soil (green line) infiltrated almost the entire rainfall input, keeping pace with the cumulative rainfall (blue line), whereas the bare soil

(red line) lagged far behind, indicating much of the rain did not percolate in Column B. Data include two monsoon seasons with a gap during the dry winter.

The daily measurements provide further insight into how each column handled individual rain events. During **heavy rainfall events**, the vetiver column consistently infiltrated far more water than the bare column. For example, on one particularly intense rain day (3 July 2025), about **24 L** of rain was captured by the open gauge (Column C). The vetiver column (A) was able to absorb essentially all of this water – over **20 L** was collected out of Column A’s base within 24 hours – while the bare column (B) only yielded **6.5 L** of percolation. This implies that in Column B, the remaining ~17 L of rain from that storm did **not** infiltrate the soil; it likely overflowed or ran off the top of the column. In another case on 5 July 2025, about **17.5 L** of rainfall was recorded, after which Column A drained **30 L** (including water still percolating from the previous day’s rain), whereas Column B only produced **4 L**. These observations show that the vetiver vegetation greatly enhanced the soil’s capacity to take in water quickly and continuously, whereas the top layer of bare soil became saturated and generated runoff once rainfall exceeded its limited infiltration rate.



It was also observed that the vetiver column continued to drain water for longer after rainfall events. In many instances, Column A would keep percolating water for a day or more following heavy rain, whereas Column B often stopped draining shortly after the rain ended (having much less water enter the soil in the first place). This led to the measured infiltration from Column A sometimes exceeding the single-day rainfall amount (the excess being water that had infiltrated during the storm but drained out over the next day or two). By contrast, Column B rarely showed delayed drainage – if the soil did not infiltrate water during the rain, the water was lost as runoff rather than stored to drain later.



Surface runoff and erosion: A clear physical indication of runoff was noticed on the bare column. After about one month into the experiment, **Column B** (bare soil) developed a ring of deposited sediment around the top rim. During heavy rains, water would flow over the brim of the bare soil column, carrying fine soil particles with it, which then dried and stuck to the rim. This showed that **surface runoff and soil erosion** were occurring in the absence of vegetation. In contrast, **Column A** (vetiver) had **no such soil deposition** at the top – the rim remained clean, indicating that little to no overflow runoff left the top of that column. The vetiver grass clump helped protect the surface: the plant's leaves and stems diffused the energy of raindrops and slowed down any overland flow, while the dense roots helped the soil quickly soak up water. As a result, Column A did not experience the surface soil loss that was evident in Column B. By the end of the study, the bare soil column had visibly lost some topsoil (and showed signs of surface crusting), whereas the vetiver column's soil surface was intact and remained porous due to the root activity.



absence of soil crust on the right drum with vetiver grass indicates no surface runoff

Discussion

The above results demonstrate the powerful impact of vetiver grass on enhancing rainwater infiltration and preventing runoff-induced erosion. **Vetiver grass increased the infiltration capacity of the soil column dramatically** – under identical rainfall input, the vetiver-planted soil absorbed and transmitted roughly 3 times more water than the equivalent bare soil. This aligns well with the known behavior of vegetated vs. bare soils. Vegetation (especially deep-rooted grasses like vetiver) improves soil structure and permeability: roots create channels and macropores in the soil, which facilitate quicker and deeper infiltration of water vetiver.org. Additionally, organic matter from root turnover can improve soil texture and infiltration rates. In the experiment, the vetiver's roots had one year to develop throughout the 1.8 m soil column, resulting in a highly permeable root-zone that readily soaked up rainwater. The bare soil column, in contrast, likely suffered from surface sealing or compaction over time (especially after repeated wetting and drying with no plant to maintain soil structure), which would reduce its infiltration rate and cause more water to pond and run off.

The vetiver grass also provided **canopy interception and barrier effects** that reduced effective rainfall intensity on the soil. The clump of vetiver in Column A intercepted raindrops and its stiff stems broke the flow of water, preventing the formation of fast runoff. Water would trickle down along the plant and spread, giving it more time to infiltrate. This is essentially the “living barrier” function of vetiver LCB hedges: as literature reports, a vetiver hedgerow acts as a physical filter strip that slows down runoff and spreads it out, allowing more uniform infiltration across the slope vetiver.org. Thus, less surface runoff is generated in the first place. In our results, the absence of any overflow from Column A (and no sediment at the rim) confirmed that the vetiver hedge completely captured the rainfall inputs without letting runoff escape. Column B, on the other hand, had no such protective cover – once the rainfall intensity exceeded the bare soil's infiltration capacity, excess water simply flowed over the top, carrying soil with it.

The findings from this column experiment are consistent with results from other studies on vetiver's role in slope hydrology and erosion control. For example, small-scale slope models and field trials have found that **vetiver vegetation can reduce runoff volumes by roughly 50–70%** compared to bare slopes springer.comvetiver.org. In one study under simulated heavy rain (188 mm/hr), vetiver strips decreased surface runoff by 18–71% and correspondingly increased the infiltration into the soil springer.com. Our experiment's bare soil column infiltrated only ~40% of rainfall (meaning ~60% was lost as runoff/overflow), whereas the vetiver column infiltrated effectively ~100% – a difference on the order of 60%, which falls in line with that range. In essence, the vetiver grass in Column A eliminated nearly all of the runoff that was occurring in Column B. This is a vivid demonstration of what has been observed in the field: **properly established vetiver LCB hedgerows can cut runoff by about two-thirds**, and in doing so, drastically reduce soil erosion vetiver.org. The reduction in runoff not only keeps more water in the soil but also means less erosive force downhill, protecting the land from gullying and nutrient loss.

An important consequence of increased infiltration is improved **water conservation**. Water that infiltrates can percolate down to recharge groundwater or be stored as soil moisture for use by plants. In agricultural contexts, vetiver strips have been noted to enhance soil moisture and extend the duration of moisture availability after rains (reducing drought stress for crops) vetiver.org. In

our study, the vetiver column retained moisture which then drained out slowly over time, indicating that rainwater was effectively moving into deeper layers (and would be available to groundwater if this were an open system). Reports from the field have indeed shown that vetiver hedges can increase groundwater recharge – one source noted an increase by as much as ~20% in areas with vetiver, attributed to the deeper infiltration pathways provided by root channels vetiver.org. Thus, the vetiver grass not only prevents the destructive aspects of rainfall (runoff and erosion) but also enhances the beneficial aspect (water infiltration to soil and aquifers).

It is also worth discussing the slight caution that increased infiltration can, in certain scenarios, lead to higher subsurface pore pressures. On very steep or marginally stable slopes, the additional infiltration from vetiver's root pathways might raise groundwater levels and potentially reduce slope stability in the short term. However, in many cases the positive effects of vetiver (reinforcing the soil with roots and preventing surficial erosion) outweigh this concern. In our controlled columns (which represent a deep soil profile), the extra water infiltrated by vetiver did not cause any failure – the column remained structurally intact. In real slopes, the deep anchoring roots of vetiver also improve the shear strength of soil significantly (vetiver roots can increase soil shear strength by up to ~30–40% as noted in literature) vetiver.org, which helps counteract any minor reduction in stability from increased moisture. Overall, the net effect of vetiver vegetation is usually improved slope stability and resilience to heavy rains vetiver.org.

In summary, the presence of vetiver grass created a **win-win situation** in our rainfall infiltration experiment: nearly all the rainfall was absorbed into the soil (preventing excess runoff) and the soil itself remained in place (preventing erosion). The bare soil condition, by contrast, led to considerable runoff and evident soil loss at the surface. These results provide quantitative support to the use of vetiver grass in slope management for enhancing rainwater infiltration and controlling erosion.

Field Case Study: Live Contour Bunding (LCB) of Vetiver grass at Matheran Foothills

To reinforce the findings of this controlled column experiment, we present a real-world case study of successful application of the vetiver-based **Saguna Vansanvardhan Technique (SVT)** implemented by our team on **Hill Number 2** at the **foothills of Matheran**, Maharashtra. This project involved the creation of approximately a total of **5 to 6 kilometers of Live Contour Bunding (LCB)** using vetiver hedges, carefully aligned along elevation contours across steep slopes. These vetiver rows were established at regular intervals to form a cascading sequence – in some areas, up to **15-20 contour LCB hedges** were installed one after another, climbing up the hillside.

After **three years of establishment**, the performance of this vegetative system has been exceptional:

- The vetiver plants have matured into robust hedges, with **leaf height exceeding 5 feet** in most places, providing a tall and dense live barrier.

- The hedges are strong enough to **physically block rolling stones** – in one documented instance, a stone weighing over **2 kg** was stopped and prevented from crossing the vetiver row, demonstrating the structural resilience of the hedge system.
- Most importantly, the hydrological impact has been profound. The presence of vetiver LCB hedges has enabled more rainwater to infiltrate into the slopes rather than run off. As a result, **2 new perennial water holes** have emerged at the top of the hill, within a **~50-acre area**, where previously there was no year-round surface water.

This demonstrates that the infiltration-enhancing and runoff-reducing effects observed in the soil column experiment can scale up to **landscape-scale water conservation benefits**. The establishment of perennial water points indicates a significant shift in the hill's water balance, most likely due to increased groundwater recharge facilitated by vetiver's deep-rooted infiltration channels. The practical success of the Matheran project confirms the value of SVT as a replicable and durable technique for slope stabilization, rainwater harvesting, and ecological restoration.



*LCB and the resulting water percolation into a
peak of the summer.*

S

iver Oil

An unusual and fascinating observation was recorded during the early percolation phase of the second rainy season. On **26th, 27th, and 28th May 2025**, the **first drained water** collected from the bucket beneath **Column A (vetiver)** had a **distinct and pleasant fragrance** reminiscent of **vetiver essential oil**. This fragrance was natural and noticeable, suggesting that the rainwater seeping through the vetiver root zone had carried trace aromatic compounds characteristic of the plant. Later, on **7th December 2025**, when Column A was dismantled and the **vetiver root system was carefully extracted**, the **soil surrounding the roots** also had a **mild but unmistakable vetiver aroma**. This special occurrence not only highlighted the presence of aromatic compounds in the root system but also served as an indicator of the depth and health of the vetiver roots. Such olfactory evidence further illustrates the **bioactive interactions between soil, water, and vetiver roots**, and adds a unique sensory dimension to the study's findings.



The majestic vertical root-clump growth of 400+ days.

Conclusion

This study measured rainwater infiltration in two 1.8 m soil columns – one with vetiver grass and one without – under natural rainfall over two seasons. The vetiver grass dramatically improved the soil's infiltration capacity, with the vegetated column infiltrating essentially the entire rainfall input while the bare soil column infiltrated less than half. The vetiver column experienced no surface runoff or soil loss, whereas the bare soil column generated runoff that carried away topsoil (evidenced by sediment deposition on its rim). These findings confirm that vetiver's deep roots and dense LCB hedgerow significantly enhance rainwater percolation and prevent erosion. In practical terms, introducing vetiver grass on vulnerable slopes can help conserve nearly all rainwater on-site – allowing it to infiltrate and recharge the soil profile – and at the same time mitigate destructive runoff and soil erosion.

Implications: The use of vetiver grass SVT Bioengineering technique in soil and water conservation can be a highly effective nature-based solution. By reducing runoff volumes and velocities by up to ~70% vetiver.org, vetiver LCB hedges protect downstream areas from flooding and sedimentation while increasing the moisture available to plants and groundwater. This experiment's clear outcome adds experimental evidence that vetiver's root system improves infiltration and that its above-ground hedge reduces surface runoff. For engineers and land managers, vetiver grass planting is a simple yet powerful Bioengineering tool to enhance slope stability, rainwater utilization, and resilience against heavy rainfall events. Future work could involve scaling up the experiment or modeling to see how vetiver impacts infiltration and runoff on larger catchment areas and over longer time spans. Nonetheless, the present results strongly

support the adoption of vetiver grass technology for sustainable water management and erosion control in hilly terrains.

Sources:

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4. Vetiver Grass Technology – *Plant Guide* (TVNI). – Describes vetiver's root system improving soil porosity and water infiltration, and hedgerows acting as living filters that slow runoff vetiver.org.
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6. **Experimental Data (2024–2025)** – Measured daily rainwater percolation in vetiver vs. bare soil columns (this study). Key observations include the vetiver column infiltrating ~1467 L vs. 465 L in bare column out of ~1127 L rainfall, and no runoff/erosion in the vetiver column compared to significant runoff in the bare column.