The Role of Vetiver Grass in Sustaining Agricultural Productivity.

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Abstract

The paper summarizes research results and field observations of the use of vetiver grass, *Vetiveria zizanioides,* and indicates its use as an important and effective vegetative hedge that when grown on the contour significantly reduces the flow of sediment from eroding sites and reduces runoff, both simultaneously, and at a low cost, compared to more traditional engineered practices. Vetiver grass has unique characteristics. The paper also sets out evidence that vetiver grass grows over a wide range of site conditions; is non competitive with adjacent crops; is not a weed; is resistant to pests and diseases; is used as a fodder for livestock; is used for stabilizing earth embankments, drainage lines, roads etc.; is fire resistant and is known to repel rodents; and needs minimum maintenance. The main impediment to extending its use and application is because of poor technology transfer systems, and the lack of training of farmers and technicians.

Introduction

This paper summarizes the findings of research and the observations of the writer in the resurgence of the use of vetiver grass as an important technology for sustaining agricultural productivity in the tropics and semi-tropics. As a result of an early initiative by the World Bank [1] vetiver grass was re-introduced to development projects in India as a low cost vegetative system for soil and water conservation. Its use and potential was further amplified in a number of papers [2, 3, 4, 5, and 6]. This paper is dedicated to summarizing the findings of a growing number of independent scientists and users of vetiver grass who, in recent years, have demonstrated the uniqueness of the grass and its use as a formidable technology for enhancing soil moisture and conserving soil.

Soil fertility maintenance and soil moisture availability are the two most important elements critical to sustainable agricultural production. The priority given to these two activities over the past 4,000 years has allowed the Chinese nation to survive and feed its large population [7], both past and present, whereas other societies have crumbled because of the failure to maintain these key activities. At a time when a great deal of attention is being paid to simple low cost technology for

sustainable agriculture, vetiver grass provides one very good, widely and easily applicable technology that is practical, proven, effective, and profitable.

The Vetiver Grass Technology (VGT), in its most common form, is simply the establishment of a narrow (less than 1 meter wide) live stiff grass barrier, in the form of a hedge, across the slope of the land. When applied correctly the technology is effective on slopes from less than 1 to over 100%. A well established vetiver grass hedge will slow down rainfall runoff, spreading it out evenly, and will trap runoff sediments to create natural terraces. All this is possible with out the use of complex hydrological data and design, and without the aid of high cost consultants and surveyors. It is truly a farmers' technology, created by farmers; one that went unobserved by most developers and scientists. Its uniqueness is in the characteristics of the plant.

Methods and Materials.

The hypothesis underlying the use of VGT was set out in a small hand book for farmers, now in its third edition, "Vetiver Grass (*Vetiveria zizanioides)*. A Method of Soil and Moisture Conservation" [8 and 9]. The claims that were made for VGT under this first edition and subsequent editions [10] were at times disputed by scientists, and as a result, have and continue to be intensively investigated by many scientists and farmers. This paper draws on these works, and is supported by the authors own observations in countries in Asia , Africa, Central America and the Caribbean. It describes the results of the tests and experiments, and cites the authors. In some instances the paper reports on observations that are not backed by research, but are conclusive for their very existence under the conditions described.

Results and Discussion.

Claim # 1. *A vetiver grass hedge-row is an effective measure for soil and moisture conservation*..

Research at ICRISAT, India [11] compared VGT with stone barriers, lemon grass, and bare ground (control) under natural (total rainfall 689 mm.) and artificial rainfall conditions. In all cases VGT was the most effective technology for reducing soil and water losses. VGT reduced rainfall run off by 57%, and soil loss by over 80%. Their results clearly showed from the experimental hydrographs the enhanced delay in release of run off from the vetiver plots, an interesting feature that could be applied as an upper catchment flood control measure. The same research team [12], confirmed that in the next year vetiver performed even better. Vetiver shows a distinct improvement in efficiency as the hedges become older and more dense. At CIAT, Colombia [13], vetiver was compared to other vegetative systems grown in conjunction with cassava. At 11 months (rainfall 1240 mm.) vetiver hedges reduced soil loss from 142 tons/ha for bare fallow to 1.3 tons/ha.for cropped cassava between vetiver hedges Rainfall run off was reduced from 11.6% to 3.6%. Other researchers have

reported similar results. Evidence [14] shows strong positive correlation between soil loss and water runoff reduction when VGT is applied on black vertisols in western India, and that VGT is significantly superior to other hedge type barriers. In Louisiana [15], demonstrations conclusively show the impact of vetiver hedges on sediment retention. In Malaysia [16] large scale experiments have demonstrated substantial sediment deposits behind vetiver hedges, in one case of about 1 meter in 1 year.

Farmers have in nearly every case reported favorably on the use of VGT. A farmer [17] has used vetiver on the family sugar cane farm in Natal, South Africa, for over 70 years as a means of stabilizing road sides. Since 1989 he has protected 186 ha. of his farm with vetiver hedges. Erosion losses have been reduced substantially and rainfall runoff was reduced to the extent that in a very serious drought in 1992 not one of his young lychee trees was lost. Vetiver grass users in Central America, amongst them those from Honduras [18], confirm that vetiver hedges are the most cost effective method of soil conservation, as do users, [19] in Ethiopia, and other African countries. The feedback from 17 farmers in Layete, Philippines [20], gives clear indication of the impact of VGT and its superiority over other systems. It should be noted that vetiver grass can regenerate from stem nodes. This means that as the sediment builds up behind and within the vetiver hedge to form a terrace, the grass will grow up with the rising terrace - in Fiji terraces with risers as high as 3 meters have been formed naturally [1] under such conditions.

There is no evidence to show that vetiver grass hedges are inferior to other types of hedge. To the contrary, evidence suggests that vetiver hedges are the most effective of all vegetative barriers.

Claim # 2. *Vetiver grass will grow over a wide range of site conditions..*

Experiments [21] with vetiver under saline and sodic conditions in Australia demonstrated that vetiver will tolerate high levels of salinity up to EC_{se} of 15 $mScm^{-1}$ without appreciable reduction in dry matter yields. Investigations [22] into the tolerance of vetiver to a range of soil pH have been carried out, and demonstrate the tolerance of vetiver to pH levels as low as 3.8 with soil Al toxicity levels of 68% - indications are that vetiver may be one of the most tolerant crop (and pasture?) species to Al toxicity. It was also demonstrated that vetiver could be established on soils of pH 9.9, and that it survived well when adequate levels of P and N were supplied. Vetiver grass has been demonstrated to grow under a wide variety of soil types, depths, and structure. The growth of vetiver on five different soil types in Malaysia [23] was compared; and although growth of vetiver differed from one soil type to another, in all cases vetiver grew reasonably well. It was also demonstrated that vetiver can be established on ex-tin mining land, leading to the rehabilitation of such degraded land. In India, vetiver grows as strongly on the black vertisols as it does on the alfasols. Vetiver grows well on upland as well as wetland conditions, demonstrating its xerophytic and hydrophytic

characteristics [23]. Vetiver's cold tolerance limit is around - 9.5° C [24], although some plants have survived short spells at - 15° C [25].

The greatest constraint to the growth of vetiver is rainfall. It grows in low rainfall areas of 300 - 400 mm, but requires greater management attention. Under these conditions it is more difficult to establish vetiver; and due to seasonal extremes, caused by overgrazing and periodic droughts etc. vetiver, like all other plants, suffers. As a rule of thumb vetiver will grow under most site conditions throughout the tropics and semi-tropics. It does best on well drained soils. It will not grow in areas that have extreme cold during winter months, and where there are perma-frost conditions. Except for the effect of temperature vetiver will grow at most altitudes. In Honduras [18] vetiver grows quite well at 2,800 meters. Vetiver hedges have been established [26] in western Ethiopia at 2,000 m. Vetiver has survived snow conditions at 3,000 meters in Lesotho [27]. Vetiver has high potential for growth in saline areas [28] in Australia, and was successfully used for the rehabilitation of the derelict sodic Ussar lands of north west India [6].

Overall evidence points to vetiver tolerating a very wide range of site conditions, including those that may be considered extremely hostile to plant growth. Vetiver will be even better adaptable to different sites as accessions are identified that are more specific to site conditions.

Claim # 3 *Vetiver grass is non competitive with adjacent crops.*

Most evidence indicates that vetiver does not reduce significantly yield of adjacent row crops. Experiments [13] in Colombia indicate no yield loss reduction of cassava when grown with vetiver hedgerows, whereas there was a 33% reduction in yield with elephant grass (*Pennisetum purpureum*) hedges. Similar experimental results are demonstrated in Maharashtra, India [30] and Malaysia[16] and confirmed by farmers from South India to Fiji. Sugar farmers in Natal, South Africa[17] and Fiji [8] report production gains.

Experiments [31] over the period 1989 to 1991 at Akola, Maharashtra, India, on Lithic Ustorthent soils under an average rainfall of 840 mm. showed that crops grown in association with vetiver hedges had superior levels of production. Average total production was 17.1% and 32.3% higher for crops grown in vetiver protected plots compared to crops grown in fields with graded bunds and across the slope cultivation respectively. The highest monetary return was recorded for vetiver associated crops - Rps 6,833 - compared to Rps 5,969 and Rps 5,065 for graded bunds and across the slope cultivation. Moisture Use Efficiency was the highest for vetiver plots, as was the level of residual nutrients. These researchers also compared the effectiveness of vetiver grass with other vegetative barriers. In all there were four comparisons - *Vetiveria zizanioides* (Vetiver Grass), *Leuceana leucocephala* (Subabul),*Cymbopogon flexuosus* (Lemon Grass), and *Chrysopogon martini* (Tikhada). Yield of seed cotton was 25.5% higher with vetiver than the untreated control,

and compared to 24%, 15%, and 11% for leuceana, lemon grass, and Chrysopogon respectively. In all cases the highest mean soil moisture percentage, profile and available moisture storage were recorded for vetiver. Farmers in the Philippines indicated that corn and rice planted near a Mura (vetiver) hedge row performed better [20]. A one year only experiment [12] on the red soils at ICRISAT, Hyderabad, India showed contrary evidence that maize when grown in association with vetiver hedges had a reduced grain yield, although the total biomass was not effected. Further observations on these plots may resolve these contradictions, and it may be appropriate to use crops, such as sorghum and millet, that are more common to the area than maize.

Although in some instances there is evidence of competition with the crop row immediately adjacent to the vetiver barrier, most experimental results, and overwhelming farmer reports indicate that there are no negative yield changes, and that to the contrary, most crops show positive responses to vetiver barriers. It should be noted that vetiver hedge-rows use up less land than other barrier systems, and thus (all other conditions remaining equal) the overall yield per unit area can be expected to be higher.

Claim # 4 *Vetiver grass is not a weed, it is not invasive.*

There is no evidence of vetiver being invasive under upland rainfed conditions [6]. There is some evidence of natural spreading under swamp conditions [32 and 33]. Nowhere is it seen as a threatening weed (note this is not the case for other hedge species such as Leuceana sp. that can become a major weed if not managed properly). Its roots are not stoloniferous, some of the accessions originating from south India rarely flower, and if they do the seeds are mostly sterile. Vetiver, probably originating from Guatemala, now grown in Louisiana has at one site not flowered for 25 years [34]. Vetiver is propagated vegetatively. In Zambia vetiver hedges at Msamfu Research Station have remained intact for more than 60 years [8]. One of the main objectives of the National Research Council's review [6] of Vetiver was to verify whether vetiver might be a threat as a potential weed. The review found that in the majority of instances vetiver was not invasive, but it strongly recommended that only the non seeding accessions be used. Evidence suggests that accessions from south India are less prone to seeding than those from north India. There are reports that accessions introduced from India to ARS stations in Mississippi were very fertile and germinated strongly. This seems not the case of the Le Blanc accessions near Baton Rouge, Louisiana, nor those of Boucard [35] at Leakey, Texas. More research is required into the flowering habits of vetiver in relation to cultivar, climate, rainfall, and day length. Molecular diagnostics [36] linked with rigorous biometric analysis were used to identify relationships between different vetiver successions. DNA was extracted from young leaf tissue. It was found that the Boucard accession, and what is known as the Huffman accession (believed to originate in Guatemala) were essentially the same genotype, and they were very different from the three accessions received from India. There are believed to be over 20 accessions of vetiver grass introduced to the United States.

Molecular diagnostics offers a means to identify different accessions and to correlate positive biological features relevant to the accession. This should result in a more scientific and controlled use of vetiver with potentially better results.

In Thailand [37] over 30 different accessions of Vetiver have been identified. These accessions often differ markedly in character and include six accessions of an upland species of vetiver identified as Vetiveria nemoralis. These accessions include some that flower, but produce sterile seed, and others that have seed that germinate more freely.

A rather broad conclusion is that at most sites vetiver has rarely been recorded as invasive, and if germinated seedlings are present, they can be easily removed by cultivation (the probable reason that farmers never see it as a problem). There are clear differences in accessions and these differences need better identification so that in the longer term the most suitable accessions can be identified and matched to site and need.

Claim # 5 *Vetiver grass is extremely resistant to pests and diseases.*

Vetiver is extremely resistant to insect pests and diseases [23 and 24]. There is evidence from India [38] that when dead vetiver plant material is effected by termites there may be an allelopathic reaction that prevents regrowth of vetiver from the center of the plant, and under severe drought conditions, new young shoots on the periphery of the plant are grazed out and the plant is killed. Alternatively, and most probably, the termite cast is too tough for the new young shoots to penetrate. Management by burning may eradicate this problem. Reports from Brazil [39] suggest that vetiver is resistant to *Meloidogyne javanica* and *M. incognita* race 1 (root knot nematodes), both serious root nematodes in tobacco. In China there have been reports that vetiver has been effected by rice stem borer [24], and although this has not effected the growth of the vetiver, the latter might act as a host plant. However in Fujian (south east China), where vetiver has been grown in close association with rice for many years, this does not seem to be a problem. In most cases pests and diseases in vetiver can be best controlled through burning, and as will be noted later in this paper burning may have an important place in the general management of vetiver hedges.

Evidence to date indicates that overall, vetiver is resistant to pest and diseases, and is not seen as a serious host plant.

Claim # 6 *Vetiver grass is not eaten by livestock.*

Where there are other more palatable grasses vetiver grass is normally ignored by livestock, this an important feature if the grass hedge is to remain intact for many years. There has been very little research carried out on the management and feed value of vetiver as a fodder. It has been observed

on many occasions, under farm conditions, that if the hedge is managed correctly, regular harvesting of young leaves is possible, and that these young leaves provide a maintenance ration. In Malaysia sheep will not eat vetiver in the field when there is an abundance of other more palatable species, but cut tops when fed to penned sheep were readily consumed. In China and Malaysia vetiver has been successfully fed to grass carp. In eastern Indonesia, under very dry conditions, vetiver was eaten by cows and horses. Under good management young vetiver leaves have a nutritive value similar to napier grass with Crude Protein levels of about 7.0%. Under good conditions high volumes of green leaf are available. In Texas [35] under irrigated conditions, production of dry matter at more than 100 tons per ha. per annum, equivalent to about 350 tons of fresh leaf, has been achieved. Reports [40] from China indicated mulch production from vetiver of 11.4, 14.7, and 17.8 tons of green weight per 100 sq. meters of hedge row over three consecutive years. Note 100 sq. meters in this case was equivalent to 230 linear meters of hedge. There is little doubt that with some improved management vetiver would make an adequate dry season fodder, particularly if combined with a high protein forage. Farmers at Gundalpet, India, have been using vetiver for centuries as a field boundary, and for fodder, where during the peak growing season it is cut once every three weeks. Reports for its use as a fodder come from many other countries including China, Guatemala, Honduras, Niger, and Mali. Some accessions are known to be more palatable - i.e. the so called "farmer" cultivar from Karnataka, which had been selected by farmers over decades as a softer and more palatable cultivar.

In areas where there are more palatable species of forage grass or where livestock are absent, users who require an inert grass that can be developed with minimum management should look to vetiver. There are excellent examples of this application demonstrated in Costa Rica [41] for the protection of mango orchards on steep slopes.

Whether vetiver will be used as a fodder will be determined by the management objectives of the user. One thing required is the identification and screening of accessions that are more palatable and manageable as a dual purpose conservation and forage plant.

Claim # 7 *Vetiver grass can be used for structural strengthening of earth embankments, drainage lines, roads, gully control etc.*

There is world wide evidence to support the use of vetiver for embankment stabilization [9, 10, 17, 27, 42]. Vetiver has been used successfully in Malaysia, India, South Africa, West Indies, and Brazil for stabilization of road sides. Vetiver has been used in conjunction with geotechnic applications for embankment stabilization in Nepal. It has been tested successfully [27] to stabilize gold mine slag heaps in South Africa. It has been used[10, 33] to stabilize flood embankments, river and canal embankments in Bangladesh. Because its great strength and capacity to absorb shock vetiver has potential in the stabilization of canal banks against the force and shock of boat wash - hence the

Panama Canal Commission is showing interest in the application of vetiver to the Canal. The Vetiver Network has received positive reports of vetiver being used to reduce erosion in small dam spillways in Zimbabwe [39], gullies in Fiji [8], and drainage ways in Guatemala, South Africa, Malaysia, and Nepal [16, 17, 41, 42]. More recently reports have been received of vetiver being used for the protection of building sites when located on sloping land [27].

VGT can be used effectively for the stabilization of irrigation channels [43]. Experiments using irrigation channels with vertical side slopes compared vetiver on unlined slopes and vetiver on polyethylene lined slopes. The side slopes planted with vetiver in the polyethylene lined channels remained vertical, and nearly so in the unlined slopes. The results indicated the high ability of vetiver to bind the soil (a sandy loam), and the potential for designing channels with much steeper slopes with the resultant saving in land area.

VGT has been used in many countries as a very effective means for gully control. Because of its strength vetiver can withstand high velocity water flows that are normally associated with gullies, and can grow up and through deep deposits of sediment that are formed behind vetiver hedges established in gullies. As a result natural steps are formed in the gullies. Where gabbions are used to stabilize gullies and waterways, vetiver, if planted in association with the structures will help stabilize them. At sites where high water velocities can be expected vetiver may best be planted from polybagged planting material to assure quick establishment, and may in the first year require protection by sand bags as well as pegging with bamboo stakes.

It is likely that vetiver will be more widely used for embankment stabilization as engineers become aware of its potential. It has a very important potential in non arable areas for gully control.

Claim # 8. *Vetiver grass is fire resistant and repels rodents and other animals.*

Vetiver is well known for its resistance against fire. This resistance has resulted in its survival in sugar cane fields that are burnt prior to harvesting. In South Africa vetiver is used to protect forestry firebreaks from erosion [27], and that this method is accepted by the forest insurance companies. Young burnt vetiver (burnt as a result of a mass of cut and dried leaf) under Malaysian conditions recovered fully in four weeks [16]. Historically nomadic herdsmen in grazing the flood plains of the Niger River in Mali, West Africa, have burnt vetiver in order to get a quick flush of grass for grazing. Vetiver's resistance and quick recovery from burning is primarily due to its protected crown and from its deep root system and associated nutrient storage that enables quick recovery. It is these same characteristics that allows fire to be used as a maintenance system for vetiver in drier areas where large amounts of dry leaf material accumulates in vetiver hedges, burning "clears" out the hedge and reduces the incidence of termite infestation.

There is conflicting evidence on vetiver's effectiveness to deter rodents and other animals. Farmers are continually reporting that rats appear to be repelled by vetiver and do not burrow into the root system. In fact on Nepal's irrigation schemes many farmers have planted vetiver on their inter-field bunds in order to reduce rat infestation [42]. Recently a forester in Papua New Guinea [44] reported that thus far (3 years), the notorious bush pigs have not up rooted vetiver grass hedges.

Claim # 9. *Vetiver grass needs no maintenance or management*

Initially in the dissemination of VGT the claim for minimum or no management was based on its use in higher rainfall areas such as Fiji and the West Indies. In these areas experience showed that on cultivated lands vetiver maintained itself well, the only maintenance being an annual cutting. Following its introduction to less favorable climatic conditions such as in the semi arid areas of central India (rainfall 500 - 600 mm.) it has been found that selection of quality planting material, planting at the correct time (under such climatic conditions the planting window is quite small), gap filling in the first year or so, planting via the use of polybags (container plants) under extremely difficult conditions, the use of fire as a management tool to eradicate excess dead plant material etc., and using different planting techniques to match different site conditions are all important management aspects that require good practical judgement. Management experiments [15, 16, 23, and 30] have shown that management plays an important role in the level of success of vetiver hedges as an erosion control system. There is conclusive evidence that just "sticking the grass in the soil and forgetting about it" does not often lead to success, for that matter most technologies fail when this approach is taken.

Studies in Andhra Pradesh [45] and in the Philippines [20] show where farmers have understood the technology and apply and manage it properly the system is effective. When government undertakes the work for the farmer,we find the farmer less committed to VGT; maintenance is not carried out and the hedge system degenerated. On the other hand VGT applied in Costa Rica [41] in a citrus orchard (free of livestock) showed no signs of deterioration with no maintenance after five years. Another study [46] shows that on very small farms (less than 0.5 ha.) farmers are loath to put any barrier across their land as they take up potential food crop production areas. In such cases we need to be more aware of farmer practices and encourage farmers to use VGT as a boundary demarcation as has been practiced for centuries by farmers in Gundalpet in south India, and by thousands of farmers outside the city of Kano in northern Nigeria.

Claim # 10. *Vetiver grass is a low cost and economic system of soil and moisture conservation.*

An economic analysis [3, 47] compared establishing vetiver grass hedges at less than $30 per ha. with more than $500 per ha. for conventional engineered systems. Economic rates of return for the

latter are around 20% compared to more than 90% for vetiver. The costs of establishing vetiver hedges varies from site to site. On gentle sloping lands vetiver hedges may be established 50 meters apart, and thus only 100 meters of hedge per ha. of protected land is required. On steep lands of 60% the distance between hedges may be 4 meters or less, requiring 2,500 meters of hedge per ha. The cost of planting material varies depending on how it is produced. It will cost more if propagated by hand in a commercial nursery, less expensive by mechanized methods, as done by the Boucard brothers in Texas, and even less if existing farm hedges are divided for replanting as new hedges. In India a farmer can dig and plant 200 meters in a day - cost $3 per day. "Commercial" vetiver nursery enterprises in India were paid in 1987 about Rupees 0.01 per planting slip. At three slips per hole planting material would cost about Rupees 300 (US $ 10 per km. of planted hedge). In Thailand good quality bare rooted "slip producers" are paid in 1993 US$ 2,600 per ha. which at 1.25 million slips per ha. is equivalent to US 0.2 cents per slip or US$ 60 per km. In Thailand polybag vetiver is produced and planted at US 62 cents per meter. The mechanized cost [35] of planting of vetiver, including cost of planting material, is estimated at about US $175 per mile. In the USA protecting 1 ha. of land on a 4% slope would, using six lines of hedge-row, cost about US $ 90.

Benefits from using vetiver grass hedges are less easy to determine. In most instances soil loss is quickly and permanently reduced, reductions of erosion losses from 143 tons to 1.3 tons per ha. in one year are not uncommon [13]. Short term yield gains have been demonstrated in India [31] resulting in estimated Benefit Cost ratios of more than 2:1. Some farmers in India have reported no crop loss in drought years when using vetiver, whilst their neighbors have lost their unprotected crops. Other benefits that should be quantified include the value of vetiver as a mulch (in China US 2 cents per kg), as a fuel (vetiver has an energy value of about 55% of that of coal), and as a fodder. Indirect benefits include value of otherwise lost soil and soil nutrients, value of increased ground water recharge, its value in upper catchment flood protection and reduced maintenance cost of embankments. If one assumes the benefits between engineered systems and vetiver grass to be the same (which they are not - vetiver's being superior) then the low cost of vetiver compared to engineered systems (about one fifth) should rank VGT as a priority technology. Detailed costs of vetiver hedge development [3] show its superiority over other systems, including engineered structures, in terms of benefit cost ratios.

Conclusions

The foregoing establishes strong evidence that vetiver meets the requirements of a long term, low cost, vegetative technology for soil and moisture conservation as set out in the first edition [9] of the handbook "Vetiver Grass (*Vetiveria zizanioides*) A Method of Vegetative Soil and Moisture Conservation". The proof not only rests in the above experimental results but by an expanding group of users around the world who seem to be voting "aye" by including VGT as part of their farm management practices. Nowhere is this more vividly demonstrated than the mass introduction of

VGT in Thailand [37, 48] over the past two years. Educating farmers in soil conservation is a slow process and needs to be accelerated. Vetiver grass is one of a number of tools that can be used in conjunction with other methods (contour tillage, no-till, appropriate nitrogen fixing cover crops etc.) to reduce soil erosion. Vetiver has special merit in its characteristics as a durable, relatively inert, and highly effective grass that when grown as a hedge halts sediment flows and reduces rainfall run off.

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